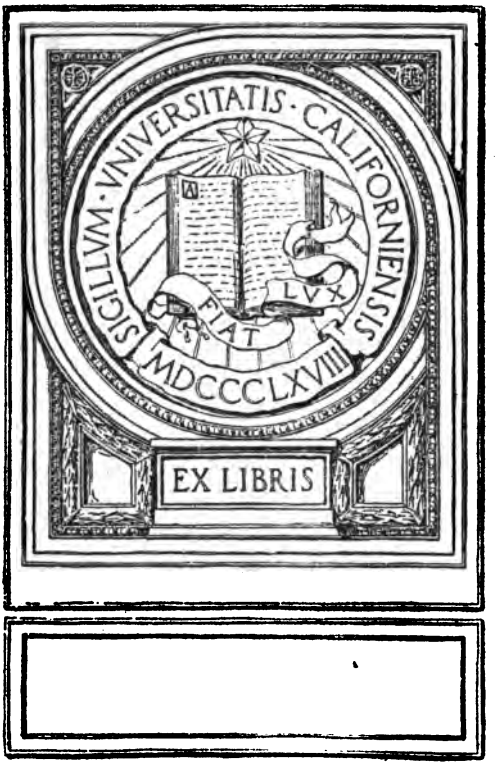
RAPID RECONNAISSANCE SKETCHING

INCLUDING

CONTOURING



RAPID RECONNAISSANCE SKETCHING

INCLUDING

CONTOURING

BY

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RAPID RECONNAISSANCE SKETCHING

PREFACE

The ability to make reconnaissance maps sufficiently accurate as to distances, topographical details and elevations for preliminary location purposes is of great importance to all engineers. This book describes in a simple practical manner and in great detail how this ability may be attained.

Rapid contouring with hand instruments may be done much more accurately than is generally believed, and the author has had many students who became so proficient that their work was little inferior to good transit or plane table surveys in accuracy and often excelled them in *the graphic representation of ground* by *correct contour spacing.*

This edition of Part III *Military Topography* is designed to fill the needs of those who do not wish to take up the subject of instrumental surveying.

PART III.

CHAPTER I.

MILITARY SKETCHING.

223. *Military Sketches* are rough topographical maps of a given area, showing in great detail the present existing features of military value with sufficient accuracy to meet all military requirements. They are intended to give to military commanders detailed information of the immediate zone of operations, and to furnish the basis for reports of reconnaissances and scouts; for the issue of orders for posting troops in position, for launching an attack, for organizing a march of concentration, etc.

224. Sketches are of the greatest importance when the operations take place in territory of which no maps exist, but in any case are essential to amplify and bring up to date the information given by existing maps. Most civil maps are on too small a scale to meet all the tactical requirements; they are also deficient in the details necessary for military purposes, such as new roads, buildings, wire fences, growing crops. *Civil Maps* often show no elevations, or their contour interval may be too large to show important cover, and the contours are usually spaced uniformly from top to bottom of all hills regardless of the actual slope of the ground, thus furnishing meagre information of the cover afforded or the best line to be held. Military sketch-

es, on the contrary, should show convex, concave and uniform slopes true to nature, and all details valuable in military operations.

SCALES OF MILITARY SKETCHES.

225. *The Field Service Regulations* prescribe that the *normal system* of scales shall be used in making field sketches as follows:

226. *Position* and *outpost sketches,* 6 inches=1 mile, contour interval 10 feet; *road sketches,* 3 inches=1 mile, contour interval 20 feet. *Place sketches* should be made on the 6 inch scale, with 10 foot contours, unless they join on to and extend road sketches, in which case they are made on the scale 3 inches=1 mile, 20 foot contours. The use of this system is of great importance to the beginner in sketching, because a given M. D., par. 25, between contours always represents the same slope, no matter which of the scales is used. If the sketcher will learn the M. D. corresponding to *one, three, five* and *seven* degrees of slope, so that he can plot them accurately from memory, he can draw contours rapidly to show slopes from 1 to 14 degrees. For example, ½ degree slope is represented by two lengths of the 1 degree distance; 2 degrees by ½ the 1 degree distance; 3½ by twice the 7 degree distance, etc. This ability to immediately convert ground slopes to map distances, as will be seen later on, is the key to rapid sketching.

MEASUREMENTS MADE IN MILITARY SKETCHING.

227. (1) *Distance,* (2) *Horizontal Direction,* (3) *Slope,* (4) *Elevation.*

Methods of Distance Measurement Used in Sketching. The units used are: (1) The sketcher's stride in inches; (2) the distance in inches passed over by the sketcher's horse per minute at a trot, and at a walk; (3) the distance in inches passed over by one revolution of a wheel; (4) 100 yards as estimated by the skilled sketcher.

228. 1. *The Stride.*—In all position and outpost sketching, except where the time is too limited, the work is done by the sketcher dismounted making the controlling measurements by pacing. Accurate measurement by pacing depends on the skill of the sketcher in maintaining a uniform length of pace. Good pacing should not be in error by more than 3 per cent on courses averaging from 300 to 800 yards.

229. *To Determine the Scale of Strides.*—The sketcher should lay out an accurately measured distance from one-half to two miles long, over ground of varying slopes. He should then pace this course in both directions at least twice, keeping a record of the number of strides with a tally register, Figure 130, held in the left hand. Each time his right foot

Fig. 130

comes to the ground the left thumb presses the registering lever. This system of keeping the record is the best possible, because the left hand is free to handle the register in the sketching work, and after a very little practice will automatically press the lever as the right foot strikes the ground, which occurs as the left hand reaches the forward point of its swing. The more nearly automatic the work of pacing and recording strides becomes, the more completely can the sketcher's attention be devoted to observing the details and configuration of the ground and the shape of the contours so essential for good sketching. Also the more automatic the pacing becomes, the more uniform and accurate will be the results. The sketcher should, from the first, remove his attention from the act of recording the strides, because by no other means can he secure uniformity; and in the actual work of sketching his mind is necessarily devoted to other things, such as the observation of the ground, the picking out of critical points, the estimation of elevations and offsets, etc. Having paced the course several times, the sketcher takes his average number of strides for the course and divides it into the total distance. The quotient is then used as his length of stride in the construction of working scales of strides. For example, suppose the distance is 2500 yards; and the recorded number of strides, 1560, 1580, 1550, 1570, 1540. The average is 1560. 2500 yards=90000 inches. $\frac{90000}{1560}$=57.6 inches, the length of one stride.

With this a scale of strides at 6 inches=1 mile is constructed.

$$\text{R. F. } \frac{1}{10560}, \quad \frac{1 \text{ inch}}{\frac{(10560)}{(57.6)} \text{ strides}} = \frac{1 \text{ inch}}{183.33 \text{ strides}}, \text{ or}$$

5.45 inches=1000 strides, from which a working scale is constructed as in Problem 1 (b) p. 9, Map Reading.

230. The sketcher now proceeds to make a traverse over the measured course, using this working scale for plotting. On completing this traverse, he measures it on his sketch and should find it to be 2500 yards to scale. If the plotted length is not 2500 yards, the stride used in sketching is not of the same length as that found in pacing the course, and the true length must be determined. Suppose the scaled distance is 2600 yards, then the length of the stride assumed in making the working scale is too long and must be reduced in the proportion

$$\frac{2500}{2600} \times 57.6 = 55.3 \text{ inches} = \text{the true length of stride.}$$

After two or three sketches have been made and tested thus over courses of known length, the stride for all future work will be determined. It should be borne in mind that *uniformity of length of stride and automatic recording* are the important things, because then the parts of the sketch are true relatively though on a slightly larger or smaller scale than intended. However, it is much easier to contour the sketch if the distances plotted are actually on the scale intended, because then the number of

contours and their spacing show correctly *the true difference of elevation* and *the true slope* between any two points.

231. 2. *Horse's Walk and Trot.*—In has been found by several years' experience at the Service Schools that horses may be rated at the walk or trot so as to furnish measurements of distance with an error not greater than 5 per cent. This is sufficiently accurate for road sketches, except possibly on the main routes of a combined road sketch where carts are preferably used. The normal method of making road sketches is mounted, therefore, except for one or two preliminary sketches. The method of determining distance by the rate of the horse's walk and trot is more accurate than is possible by counting the horse's stride and sufficiently accurate for military road sketches, as the errors tend to compensate one another. Counting strides is also objectionable because the attention which must be devoted to it prevents that study of the ground so essential in road sketching. Unless the horse has a very steady walk and trot, it will not take a sufficiently uniform gait of its own accord. The sketcher must, therefore, carefully observe his horse's gaits and be able to *know if the horse is moving too fast or too slow.* For instance, a horse moves freer on starting out in the morning than later in the day when he is tired. His gait is slower going away from his barn than coming home, especially if it is near feeding time. A horse moves slower and more uniformly when alone on the road than when

other horses are passing him. Two horses of equally uniform gaits trotting side by side move with greater uniformity than either one of them alone but if one of the pair is much more steady than the other, this one should be ridden in advance. The sketcher should learn the peculiarities of his horse and take necessary measures to keep him up to his proper gait when he lags and hold him in when he rushes ahead.

232. *To determine a horse's rate,* he should be ridden over accurately measured courses until the time required on any of the tests for the distance does not differ from the average by more than 5 per cent. This should be done for the walk and for the trot. In these tests, the sketcher should observe carefully the gaits until he is able to know when the horse is going at the proper rate and cause a change of gait when necessary. If the sketcher is to have an assistant in sketching, the two horses should be tested together and in the manner in which they will later be used. For instance, if the assistant is to ride beside the sketcher, the horses should be rated thus. If the assistant's horse is to keep the gait going in front, they should move in this order in the test.

It is sometimes found of assistance in keeping a uniform gait for the sketcher to rise to the trot because this enables a good estimate to be made as to the uniformity of time of the strides. Care must be used not to rate the horse faster than he can travel for a day's work. Most of the time in mounted

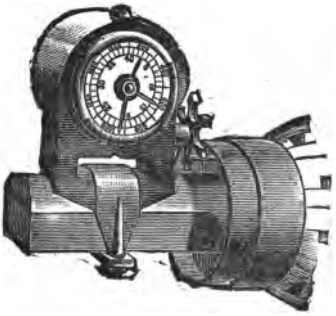
sketching is spent at the halt, so rapidity of gait is not of much advantage. A slower gait gives better opportunity to the sketcher to study the ground forms and details. The trot is the habitual gait in mounted sketching and should be always used except on steep slopes. No correction need be made for grades, even in hilly country, because they do not appreciably affect the horse's rate; but the rating should be done over ground of the same nature as that to be sketched. Where the grade is steep enough to make any allowance, it is necessary to take up a walk to protect the horse from being staved up in the shoulders; and, therefore, an accurate determination of the rate of the walk up and down steep hills is very important and should be found under these conditions. As soon as the sketcher is positive of the horse's gait, he constructs scales of minutes, halves and quarters, see problem 3, par. 19. The scales should be tested in actual sketching, as described for the stride, because this work often causes a modification of the gait.

Rules for correcting scales: *A sketch smaller than intended (scale too small) is caused by having assumed the horse's gait to be slower or the stride shorter than they actually are.*

Should it be required to *make a mounted sketch on an unrated horse* when no time is available for rating, the sketcher should use the scale of average walk and trot; *a mile in sixteen minutes at a walk; and in eight minutes at a trot,* see figure 136, p. 242. He should be able to keep the horse very close to

these gaits, by his knowledge of horses' gaits in general.

233. 3. *The Distance Passed Over by a Revolution of a Wheel.*—This method of determining distance is of great value in making road sketches, especially in combined work, because of the uniformity secured. The length covered per revolution is best determined by driving over a measured course and *dividing the length of the course by the number of revolutions.* This gives better results than measuring the circumference of the wheel, which slips and has side motions along the road. The rating course should be over average rolling ground to prevent measurements in the actual sketching from being too long on the hills where the wheel measures along the slope instead of the horizontal distance as it should. The number of revolutions is recorded by an *Odometer,* fig. 131 (a), attached to the axle of a front wheel and oper-



131*a*

131*b*

ated by a steel pin driven into the end of the hub. This type is called the *Bell Odometer* and registers miles and fortieths of a mile (44 yards) and, as each mile is completed, a bell rings. This type is more accurate than the pendulum type usually furnished, figure 131 (b), and is very convenient for sketching because the readings are easily visible from the seat of the wagon. With this odometer a scale of miles and fortieths would be constructed so that plottings would be directly from dial readings. Readings are continuous up to 1600 miles, and the most serious objection to this type is that there is no device for setting back to zero. A Veeder odometer reads tenths of a mile, and may be set back to zero. The pendulum type is practically useless in sketching, because it must be removed from its case for each reading. In case no odometer is on hand, a piece of white cloth may be tied around the tire and the rotations of the wheel be recorded on a tally register by an assistant. If there is no measured course available over which to determine the length of one revolution, the circumference of the wheel is found by multiplying the diameter by 3.1416.

234. 4. *Estimation of Distances.*—An essential qualification for a rapid and accurate sketcher is the ability to estimate distances with less than ten per cent error up to about six hundred yards and within fifteen per cent up to a mile. This can only be acquired by constant practice in making estimates of various distances and then verifying the

estimates by accurate measurement. The best possible method is in connection with stadia surveying, which gives instantly the true distance to the point observed and enables the sketcher to determine whether his natural tendency is to make his estimates too large or too small. Even if no surveying work is done, it will pay the sketcher to secure a rodman and a transit and make a series of estimates verified by stadia readings. If the rodman is mounted the readings can be taken rapidly at widely differing distances and across different kinds of ground without loss of time. The sketcher can, at the same time, estimate and check slopes by vertical angle readings; and differences of elevation, using the Cox Stadia Computer, p. 127 Military Topography. A few hours' work occasionally with the transit and stadia in practicing estimates of distances, slopes and elevations will add materially to the sketcher's ability.

Estimates of distance should be made in yards and one hundred yards should be definitely fixed in mind as a reference unit. In all estimation of distance the sketcher should bear in mind the effect of conditions of ground and light on estimates.

235. *Objects appear nearer than they really are*:

1. When the sun is behind the observer and the object is in the bright light.

2. When seen over a body of water, snow or level plain.

3. When down below the observer.

4. When in high altitudes and very clear atmosphere.

In the above cases add to the normal estimate.

Objects seem further away than they really are:

1. When up a steep hill from the observer.
2. In poor light such as fog.
3. When seen across undulating ground.

In the above cases subtract from the normal estimate.

Objects are distinguishable to average eyes at the following distances:

Nine to twelve miles, church spires.

Five to seven miles, windmills.

Two to two and a half miles, chimneys.

Two thousand yards, trunks of large trees.

Six hundred yards, individuals of a column.

Five hundred yards, individual panes of glass in windows.

Four hundred yards, arms and legs of dismounted men.

Each man's eyes are different and the sketcher should learn for himself at what distances objects can be seen by him and their appearance at different ranges, by *noting objects on the ground and scaling their distances from a good map.*

Telegraph and telephone poles are usually set at fixed distances along any one line, so that the sketcher, by pacing one interval (or better, by dividing a known distance by the number of poles contained, to secure their average distances apart), may then make accurate measurements as far as

the poles are visible. There may be lines of railway telegraph, of different telephone companies, power lines (distinguished by very large insulators) and street railway lines. The average distance between street railway or telephone poles is usually one hundred feet. The interval on each class of lines in the vicinity of his station should be learned by the sketcher. In those parts of the country where the land is divided into sections the *hedges* and *fences* are usually at 220, 440, 880 yards apart.

THE ESTIMATION OF GROUND DISTANCES DIRECTLY AS SPACES ON THE SKETCH.

236. When the sketcher has learned to estimate distance with accuracy, he plots these estimates with his scale of yards to locate detail on his sketch. The next step in his training is in learning to estimate the map space corresponding to a given ground distance. This is rapidly acquired by using a scale of hundreds of yards as the unit of plotting. The map distance of 100 yards is .34 inch, at 6 inches to 1 mile, or about $\frac{1}{3}$ inch; 100 yards at 3 inches to 1 mile is about $\frac{1}{6}$ inch. The sketcher should plot, by estimation, 100 yards, then test it with his scale and repeat until he can do it with no appreciable error. It is then easy to plot half miles and miles by estimating $1\frac{1}{2}$, 3 or 6 inches, for representing distant objects not required to be exactly located. The greatest importance of estimating directly the map equivalent of 100 yards, and hence its multiples, is in plotting contours on the sketch directly from their estimated positions on the ground, see par.

274. Facility is acquired in this estimation of the ground location of contours and their map representation, by taking an accurate map made on the normal scale system, and having estimated the contour's ground position and then having drawn as accurately as possible its map equivalent, compare the result with the same contour on the map. Repeat these steps until you *can trace with accuracy the contour on the ground and plot it as shown on the map.* It will soon be possible to almost imagine you can see the contour following the various curves on the ground.

CHAPTER II.

SKETCHING METHODS OF MEASURING THE HORIZONTAL DIRECTION OF AN UNKNOWN POINT FROM A KNOWN POINT.

237. *B is Located from A using the plane table method,* by pivoting the ruler on *a* and directing it toward B, figure 147, p. 284, then drawing a line along the ruler in this position, on the oriented Drawing Board, par. 268. This plots the angle made by *a b* with respect to the magnetic meridian without an actual reading of its value in degrees; and is the method constantly used in what is known as the plane table (or sketching case) method of sketching. This method is the one most generally used, and is advocated in preference to all others on account of its greater accuracy, simplicity and rapidity. The plane table method and the compass and protractor method have been tested side by side for a number of years at the Service Schools, until now every one prefers the former, see par. 240.

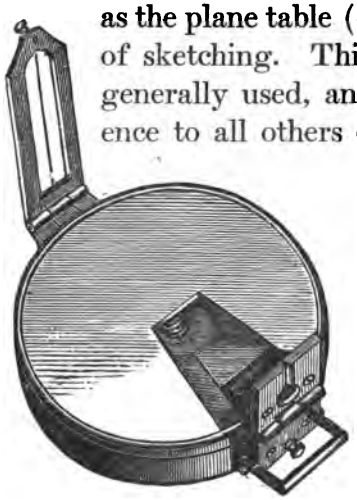


Fig. 133

2. By reading the azimuth (angular direction with respect to the meridian) of B from A with a Box Compass,* or Prismatic Compass, figure 133. The angle read is then plotted by means of an Abbott's Protractor, figure 134. In reading a box

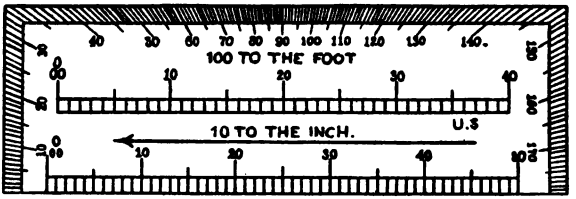


Fig. 134

compass the needle should be damped, by pressing the left thumb down on the stop several times, so that it will settle correctly. To save time, the reading may be taken at the middle of the swing of the north end of the needle.

*To read an azimuth with the box compass, partly close the lid until it makes an angle of about 120 degrees with the plane of the compass face. Then hold the compass in the left hand, in front of your body, and you will be able to see the reflection of the sighting line (*a-b* figure 12, Map Reading) in the glass cover. This reflection of *a-b* should be made to pass through the pivot while *a-b* is pointed toward B, at the time the reading is taken. The reflection will lie through the pivot only when the compass face is horizontal, thus giving the true horizontal angle desired.

To read an azimuth with the prismatic compass: The two sight leaves are revolved into position perpendicular to the face of the compass. This brings the prism directly over the graduated circle on the card. Now, holding the compass in both hands, place the eye at the peep hole in the rear sight vane. Look through the two sights toward B, at the same time damping the compass card by pressing the stop just under the front sight vane. You will now see the proper reading in the prism at the same time observing B. In this compass the "index" (line of sights) moves while the circle is fixed. In the box compass the index (needle) is fixed while the graduated circle moves with the sighting line.

238. *To Plot an Angle with the Protractor,* lay it along the meridian through the plotted position of the occupied station, the zero at the north, the center of the protractor on the station point. Make a light dot on the paper in extension of the angle read, and draw a line through this point and the station. The protractor is so graduated that it is laid on the east side of the meridian for plotting angles from zero to 180°; from 180° to 360° the protractor is turned over to the left side of the meridian. An arrow drawn on each side of the protractor will assist in rapidly placing it in position with the proper end north. In case the compass is graduated so as to give angles different from the azimuths of a normally graduated compass, mark on the protractor in ink the readings actually given by the compass.

239. *To Locate a Point D,* figure 147, p. 284, *by intersection with compass,* from two plotted points A and X, is accomplished by reading the azimuths of the unknown point from A and X, and protracting the readings from *a* and *x*. The intersection of these two lines is *d* on the sheet.*

240. *A Point Z, figure 147, may be Located by Resection on Two Plotted and Visible Points C and K, with compass and protractor* as follows: At Z read the azimuth to K and to C. Then lay the

*In all discussions of the ground and its corresponding map or sketch CAPITAL LETTERS are used to refer to points on the ground, and small *italicized letters* to points on the sketch. For example, figure 148, p. 284,A is a point on the ground and *a* is the corresponding point on the sketch.

protractor on the meridian through *k*, and plot the reverse azimuth, that is the difference between 180° and the azimuth Z K. Similarly plot *c z* from *c;* the intersection of the two lines locates *z* on the sheet. The protractor method has one advantage in that the Board need not be oriented before making observations along the traverse or for intersection and resection. The Board must be approximately oriented, however, for sketching in details. Before going out to work, meridians should be ruled at ½ inch intervals over the sheet, as it is difficult to draw parallel lines rapidly in the field. Except for the above differences noted in making locations, the compass and protractor method is the same as the plane table method.†

†**The Advantages of the Plane Table Method** are so many as compared with the compass and protractor method, that all sketchers are strongly advised to adopt the former.

Some **Advantages of the Plane Table Method:**

1. Once the board is oriented, it is difficult to get an incorrect sight because the ray is drawn while the ruler points toward the object.

2. It teaches the necessity of keeping the sketch constantly oriented, which is a most valuable habit in map reading as well as in sketching.

3. Greater rapidity is possible because of the smaller number and greater simplicity of sketching appliances.

4. By its use far greater skill is acquired in mastering ground forms and in learning to estimate directions.

5. **In using a compass and protractor, the following errors are liable to occur:** (a) Incorrect angle reading due to failure of compass needle (or card of prismatic type) to settle correctly; (b) failure to read the angle correctly; (c) failure to plot the angle read; (d) failure to adjust correctly the protractor on the meridian and the station point; (e) errors due to local attraction (see par. 62) which can be thrown out in the plane table method by back sight orientation.

INSTRUMENTS REQUIRED IN POSITION AND OUT-POST SKETCHING AND THE METHODS OF USING THEM.

241. 1. *Drawing Board with attached compass or declinator,* figure 135, supported on an improvised tripod or camera tripod.

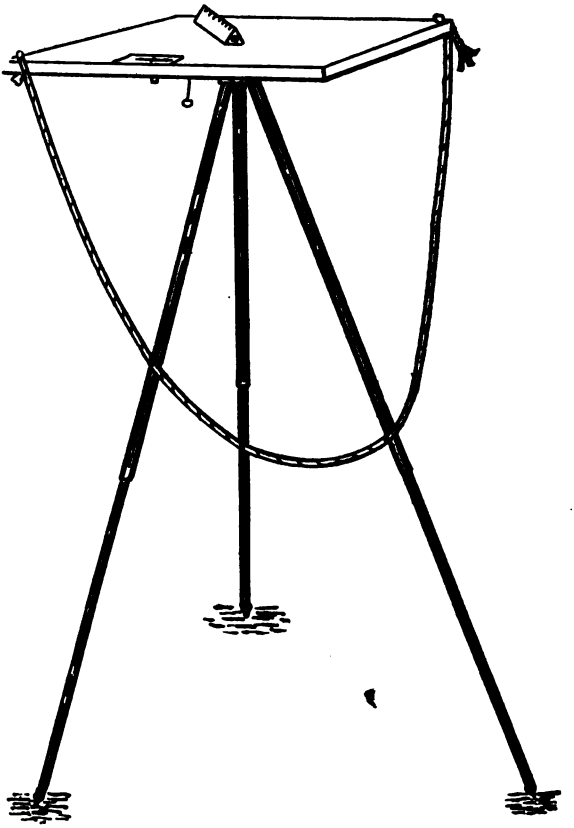


Fig. 135

2. *Loose Ruler,* figure 137, p. 243, with scale of hundreds of yards, scale of sketcher's strides, and scale of map distances, figure 136.

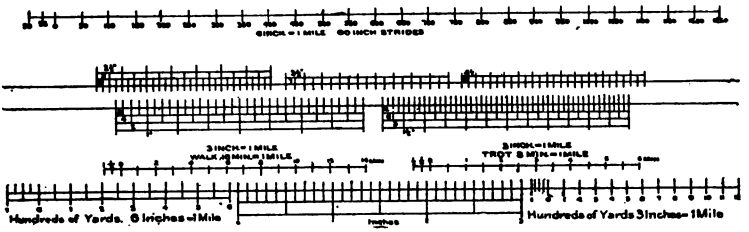


Fig. 136

3. *A Slope or Elevation Instrument*: (a) Service clinometer, figure 138, or (b) Abney clinometer, figure 140; or (c) slope board, figure 137; or (d) Aneroid Barometer figure 141, p. 249, or (e) Hand Level, figure 142, p. 251.

4. *Field Glasses.* (Useful for distinguishing distant points).

5. *Tally Register,* figure 130.

242. *The Drawing Board* should preferably be about 13x14 inches, with a trough compass set in a front edge. There is thus available a drawing surface of about 13x13 inches, which allows two miles of position sketch to be made with enough extra space to secure the paper to the board.*

Having a board of this size obviates the necessity of orienting it in any special position to get the area on the sheet. *A tripod* may be quickly made of three sticks about four feet long lashed together a foot from the top. A light folding camera tripod, figure 135, arranged to clamp in any position is very satisfactory. This tripod telescopes

*Since the above was written the U. S. Engineer Department has purchased a number of these Boards for trial, according to plans of the author.

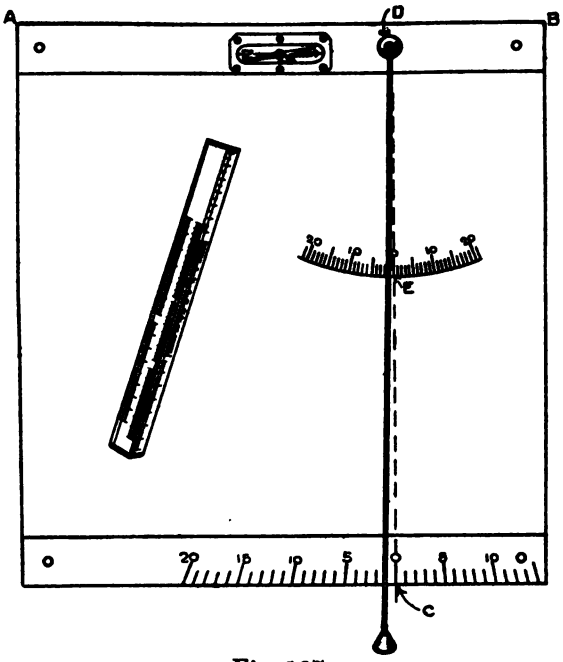


Fig. 137

from a length of 4 feet to 13 inches and is convenient for both road and position sketches.*

An ordinary box compass may be secured to the board instead of the declinator. The compass can be easily attached by screwing it to a piece of cigar box top or a piece of brass, and then screwing this to the back of the board with the compass projecting.

243. *The Loose Ruler* furnishes a well defined sighting line and carries all the scales required in the work of sketching. It is made of a triangular straight-edged piece of wood, with a hole in each

*For sale by Photographic Supply Dealers for $2.00.

end ⅜ inch diameter x 2 inches deep, filled with lead to give weight to the ruler so that it will remain fixed in position while lines are drawn by its side. On this ruler is pasted a sheet of paper, figure 136, containing scales of hundreds of yards, map distances, and inches. On one blank face the sketcher draws his scale of strides; and on another those of walk and trot of his horse, as shown in the figure. The M. D.'s and scales in figure 136 are reduced one-half. The ruler has a brass ring in one end for attaching to the sketcher's shirt. A coat of shellac makes the paper water-proof. Rulers complete may be purchased from the Secretary, Army Service Schools, Fort Leavenworth, for 35 cents each, and will be found a valuable aid in rapid sketching. For sighting up and down steep slopes a vertical pin stuck in the top of the ruler at each end gives a good line of sight.

244. (a) *The Service Clinometer,* figures 138 and 139, consists of a pendulum B, with an attached

Fig. 138

arc graduated in degrees and half degrees rotating about the pivot N, and a mirror H, all in a brass case. In figure 139 the front of the case is re-

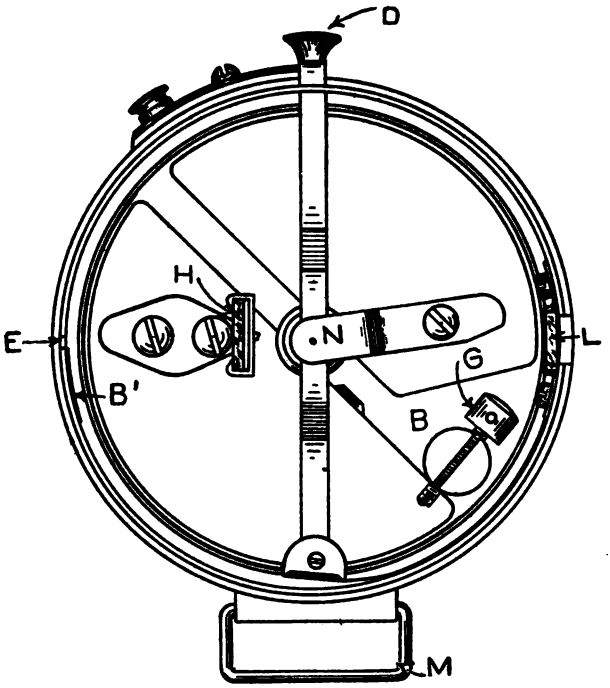


Fig. 139

moved. The observer sights the object through the peep-hole (E) and L, at the same time seeing the scale of degrees inside the rim at B′ reflected in the mirror H. The pendulum is allowed to swing freely by first sliding back the bar and pressing the stop D. The reading is taken when the pendulum comes to rest and the desired spot is at the same time sighted. *The pendulum should not be stopped to take the reading as this displaces the scale.* By

holding the clinometer so that the zero of the scale is in the center of L, a good hand level is thus secured.

245. *To Test the Service Clinometer.*—Hold the clinometer, stop uppermost, against a post A, with E L, figure 139, on a level with its top and sight the top of a second post, B, 50 or 60 feeet distant. Suppose the angle read is minus 3 degrees. Similarly sight the top of post A from B. Suppose this reading is plus 2 degrees. Add the two readings and divide the sum by 2. The correct slope from A to B is then

$$\frac{3+2}{2}=\frac{5}{2}=2\tfrac{1}{2} \text{ degrees.}$$

The clinometer gives minus readings too large and plus readings too small by $\frac{1}{2}$ degree. This error may be corrected by screwing G to change the center of gravity of the pendulum; or every minus reading must be decreased and every plus reading increased $\frac{1}{2}$ degree. Before starting each day's work, the correction to be made should be written on a corner of the drawing sheet thus: *Decrease minus (down) readings by $\frac{1}{2}$ degree; increase plus (up) readings by $\frac{1}{2}$ degree.* In using this clinometer, its flat sides should be held exactly vertical, preferably against some fixed object; and, *on completing the readings at any station, the sliding bar should be forced under the stop D to lock the pendulum.* This clinometer is one of the best types of hand instruments available for measuring slopes, but must be handled with care to prevent its being

thrown out of adjustment. Its adjustment should be tested before each day's work.

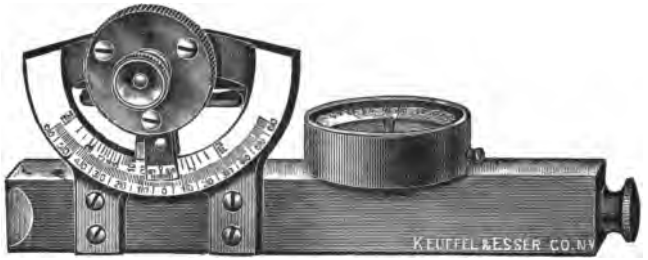


Fig. 140

246. (b) *The Abney Clinometer,* figure 140, consists of a sight tube, with a graduated arc and a level tube with index arm attached. Under the center of the level tube is an opening in the sight tube just above a mirror, in which the image of the bubble is seen by the observer as he sights the object. The bubble is placed in the center of its tube by turning the index arm until the bubble appears to be bisected by the horizontal wire across the end of the sighting tube. The reading of the index on the arc, when the bubble is at the center, is the slope of the axis of the tube with the horizontal. The bubble should be in the center of its tube when the reading of the index is zero and the tube level.

247. *To test* this, lay the clinometer on a smooth topped nearly level post. Draw lines around the four edges of the sighting tube, and read the slopes of this position of the tube. Reverse the clinometer within these marks end for end and read the slope. These two readings should be equal in

amount, one plus, the other minus. If they are different, add the two readings, divide the sum by 2 and set the vernier at the result on the *same side* of the zero as the last reading. By means of the adjusting screws, bring the bubble to the center of the tube.

248. (c) *A slope board,* figure 137, is a device consisting of a plumb line and graduated arc placed on a drawing board for measuring angles of slope. When a point is sighted along the edge AB, the plumb line makes the same angle with the perpendicular DC, that AB makes with the horizontal, and, therefore, gives the angle of slope. Such a slope board may be constructed as follows: Lay off a perpendicular to AB along the line CD, and on it take DE=5.73 inches. Describe a semi-circle with this radius and lay off from E toward A and B successive distances of one-tenth inch along the arc. These are degrees from CD, because one degree in a circle of 5.73 inch radius gives a chord of one-tenth inch. These degree marks are extended to the edge of the drawing board with a ruler, as shown in the figure. To read slopes, attach a plumb line at D, sight the object along AB, holding the front of the board vertical. When the plumb line comes to rest, press the string against the edge of the board with the finger and read the angle marked. The result should be correct within one-half degree on still days; but if the wind is blowing, good readings cannot be secured. The slope board is easily made and is valuable for a sketcher who has no good clinometer.

With a slope board, estimates can be checked until the different slopes are learned. It is also useful for reading slopes of hills in profile, that is from a position off the hill from which a good view along the water shed is possible. To do this hold the board parallel to the front of your body, with the lower edge parallel to the slope of the hill, at the same time noting the angle marked by the plumb line. The Abney clinometer can be used

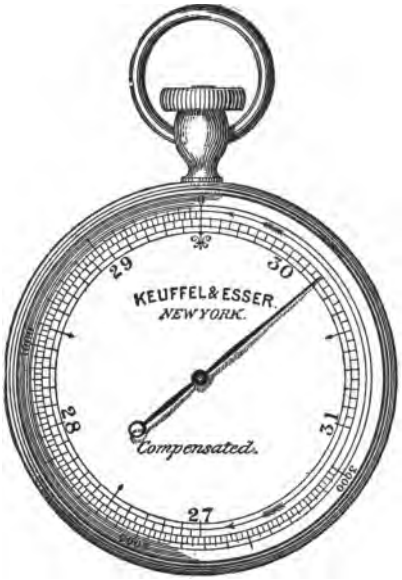


Fig. 141

in the same way. This method is particularly useful in reading the slopes of hills so convex that a view directly down the water shed can not be obtained.

249. *The Aneroid Barometer,* figure 141, has a scale of elevations in feet and a scale of heights of

a mercury column in inches on its face. The scale of feet is adjustable so that it may be set at the elevation of any known point. The aneroid barometer measures the pressure of the air, and since this pressure is usually changing, the elevation of any point would not be read the same on the scale at different times. This change, due to changing air pressure, is not over 20 feet per hour in fairly settled weather. If, therefore, the sketcher sets the scale of feet at the known, or previously found, elevation of a station *immediately before moving to another,* the error in the determined elevation of the second station would be that due to the change of air pressure in the few minutes required to go this distance, probably less than 5 or 10 feet. This constant resetting of the scale may be avoided by reading the barometer just before starting and immediately on stopping, to get the *difference* of the two elevations. The barometer should only be used thus in finding the successive differences of elevations from station to station. The results obtained with the barometer as above described are sufficiently accurate for military sketches because of the very gradual distribution of the error over the entire sketch. There are conditions of air, however, in which the barometer readings are changing too rapidly for use, and therefore the sketcher must be able to proceed with the sketch, using other methods for determining elevations.

The barometer should be carried in an inner pocket to keep it at as uniform temperature as possible.

The readings should always be taken with the barometer held in a uniform manner. The best method is to hold it vertical by its ring about 2 feet from the face during the reading. The face of the barometer should be lightly tapped two or three times with pencil or finger nail to prevent the pointer from sticking. The rate of change of the barometer should be tested every 15 minutes for about an hour before starting to work to find if the weather conditions are sufficiently uniform to admit of its use.

Fig. 142

250. (e) *The Hand Level,* figure 142, has a sight tube similar to that of the Abney Clinometer. It has the great advantage that it practically can not get out of adjustment. It is a valuable sketching instrument for determining a horizontal line, and with degrees etched on the object glass vertical angles can be read rapidly and accurately.

THE ESTIMATION OF SLOPES.

251. The ability to estimate correctly the general slope between two points is important for accurate contouring. It is best learned with the transit and stadia as described, par. 234. The sketcher should also have a carefully adjusted clinometer, see par. 245, preferably of the Service type, and make a systematic series of estimates of slopes over

various kinds of ground, verifying each estimate with a careful clinometer reading. The Abney Clinometer or Slope Board may be used if the Service Clinometer is not available. In reading a slope with a clinometer, the sketcher should sight some *definite object,* as a tree, at a point above the ground equal to the height of his eye, to get a line parallel to the surface of the ground. Some sketchers in reading an important slope take a prone position and sight just off the ground at the desired point, thus getting more accurately the height from the ground of the point to be sighted. The prone position also gives a steadier position for the clinometer, unless it can be rested against a post or tree.

In determining slopes by clinometer reading or estimation the habit should be formed of considering the slope from one definite point to another on the ground, and not simply from one locality to another. If no clinometer is available, a slope board should be constructed, see par. 248, and the estimate of the slope checked with careful readings. The slope board should be used for this purpose only on still days, when good readings are possible.

252. Both horizontal and vertical angles may be estimated with considerable accuracy by determining the number of degrees subtended by the sketcher's hand or finger held at arm's length from the eye. The average angle thus subtended by the hand is about $8\frac{1}{2}°$, but its exact value must be found by each sketcher for himself. The arm is extended full length in prolongation of the shoulder (rath-

er than to the front so that the distance from eye to hand will be constant), palm up for horizontal and to the front for vertical angles, fingers perpendicular to the palm. The sketcher takes position about 20 or 30 feet from one of the walls of the room and locates the point on the floor, above which his eye comes, when looking past his shoulder and hand held as described. He notes on a rod, or other foot and tenths graduation, against the wall the points visible past the middle joints of the first and fourth fingers. A transit (or box compass) is placed above the point on the floor over which the eye was located, and the angle between the two marked points is read. Similarly, the angle for one, two and three finger widths may be determined. Horizontal angles can be quite closely estimated by laying off successive "hands" between the two points considered, being careful to rotate the body so that the arm will always be in the extension of the shoulder.

253. Instead of thus using the hand at arm's length, the sketcher may similarly determine the angle subtended by one, two inches, etc., held at the fixed distance of 28.6 inches from the eye. Mark on a string a 28.6 inch length; hold the sketching ruler at one end and the eye at the other end of the string; then one inch on the ruler thus held subtends an angle of 2°.

254. *To estimate vertical angles,* the sketcher must learn to *trace a contour*—that is, to be able to place the hand or ruler in the horizontal plane of

the eye. To do this, mark a number of points around the room at the exact height of the eye. Practice sweeping an arc with the arm at such height that the sight over the finger passes through the marked points. Note carefully the position of the arm during these exercises, and in a short time a very accurate horizontal can be thus marked. This practice is of assistance in noting the position of contours, in determining a reference plane from which to estimate vertical angles and differences of elevations, and in marking points of equal elevation forward on a traverse.

255. After considerable practice it will be possible for the sketcher to estimate slopes with sufficient accuracy by simple observation of their general appearance. Similarly the sketcher soon learns *to trace the contour on which he is standing,* and the position of those above and below it by noting the slope of the ground at various critical points. For example, having estimated the location of the 840 contour from K (Figure 148, p. 284), the 850, 830, etc., are drawn in by eye to show a $2\frac{1}{4}$ degree slope along *r w,* a $1\frac{1}{2}$ degree at *h,* etc., with proper attention to the character of the intermediate ground.

If the sketcher can secure an accurate map made on the normal scale system it will increase his ability in estimating slopes as well as map distances corresponding thereto, to go into the field and *make careful estimates and check them from the map.*

256. *A mistake often made* by sketchers is to

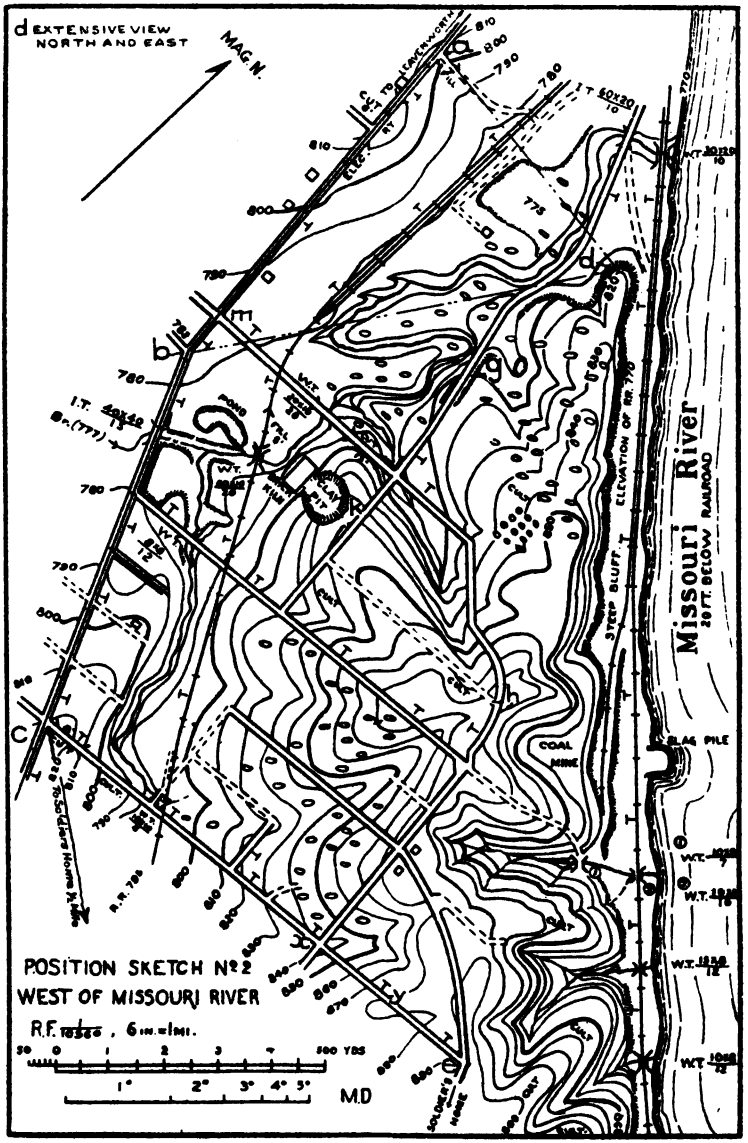


Fig. 143

estimate slopes, distances and elevations, before they have a definite idea of these units. Such estimates are but guesses and are fatal to good sketching. It is equally incorrect to suppose that all proper estimates are only guesses, because it has been repeatedly demonstrated by student officers at the Service Schools that rapid sketches, which equal or even surpass careful surveys in the graphic representation of ground, can be made without slope or elevation measuring instruments.

The sketch, figure 143, is an exact reproduction of a position sketch made in eight hours by a student officer* of the School of the Line. It is a more accurate map than that made by a previous survey of the same area in which controlling distances and elevations were measured instrumentally,—both in detail and in contouring and it is equally as correct as to horizontal distances and elevations.

THE ESTIMATION OF DIFFERENCES OF ELEVATION.

257. *The ability to estimate accurately differences of elevation* is of the greatest value in rapid contouring, because these direct estimates of elevation are found to be more nearly correct than the elevations determined by estimation of slope and distance. Elevations found from slope and distance are affected by errors in both slope and distance. If the slope is correct, but the distance too great, then the map distance (M. D.) for the slope is contained too many times in the plotted distance, giving too great an elevation.

*Captain Manus McCloskey, U. S. Field Artillery.

258. *Method of Making Estimates of Elevations.*—Having first learned to determine a horizontal plane (using hand level, clinometer or extended arm) the elevation of the unknown point above or below this plane is estimated by comparison with the heights of objects in the vicinity, such as telegraph and telephone poles, trees, horizontal lines on buildings and bridges (copings, window sills, etc.). The height of main line telephone or telegraph poles is usually 25 or 32 feet; of street railway poles about 25 feet; trees in a full grown orchard 15 to 20 feet; full grown oak trees 40 to 75 feet; the height of an ordinary story of a brick house (window sill to window sill) 10 feet. The sketcher should learn the height of such familiar objects in the vicinity of his station. In estimating the height of any object to be used as a reference, it is well to *keep in mind a well known value such as 10 feet* and imagine this applied successively to the object.

Suppose the sketcher is standing on a hill, looking in the direction of the traverse, across a valley toward another hill. He makes a careful estimate of the point (or locates it through his hand level) at which a horizontal plane strikes the hill across the valley. Then by observing the position of the bottom of the valley with reference to this plane, the sketcher estimates the difference of elevation as so many telegraph poles, etc., below the plane. The result should never be out more than one-half contour interval. The best method of checking these estimates, except by the use of transit and

stadia, par. 234, is to *consult an accurate map* after making the estimate and see the difference in elevation shown.

259. By *carrying forward with long sights,* (using hand level or clinometer at zero), points of equal elevation along a traverse, elevations throughout a day's road sketch can be obtained with sufficient accuracy. Another assistance in carrying elevations and in securing correct contouring, is the *uniform slope of streams.* The surface of a large river is practically horizontal so far as the requirements of a day's sketch are concerned. The Missouri river for instance, has a surface slope of only 6 inches per mile, or only 7½ feet in 15 miles of length. Hence wherever the sketch approaches the river, there is furnished a reference for elevations. The same principle is true of smaller streams, which usually, over considerable length, have a practically uniform rise, as 10, 20, etc. feet per mile. Having determined this rise, the elevation of each crossing of the stream is thus known. Often in sedimentary formations, an *outcrop of rock* will always occur at the same elevation. The sketcher must learn to observe all topographical features and make use of them in his estimates.

MILITARY SKETCHES SHOULD SHOW:

260. *All lines of communication*: Roads, trails, railroads (with towns to which they lead, and railroad stations); rivers, lakes, canals, telegraph and telephone lines.

All objects giving cover or forming obstacles:

Woods, tall growths of grain, swamps, unfordable bodies of water, ravines, rugged cliffs, stone walls, fences, hedges, cuts and fills.

The configuration of the ground: Contours showing all hills in their true location and shape; the character of their slopes and their relative heights; all ravines and slight undulations affording a sheltered line of movement to troops.

All easily distinguished landmarks: Isolated trees of unusual type such as lombardy poplars; houses, especially those of stone and those at cross roads; villages and towns to show the general plan of streets and houses.

All military dispositions: Defensive works (trenches, saps, etc.); bodies of troops drawn to scale.

All forms of constructed obstacles and demolitions, as wire entanglements, mines, etc.

The vulnerable points of lines of communication: Bridges, culverts, locks and dams, ferries and fords, with the character of each.

All stores and supplies for men and animals: Water supply, grazing grounds, storehouses of grain, etc.

A title, giving the locality sketched, the sketcher's name, a scale of yards, the R. F., a scale of M. D.'s, and the magnetic meridian.

262. Figures 144 and 145 show the *conventional signs prescribed in Field Service Regulations* for field sketches. Fig. 18, p. 42, Map Reading, shows additional signs for maps, but the sketcher in mak-

ing a topographical reconnaissance will rarely have sufficient time to fill his sketch with symbols, and equal clearness, with much greater rapidity of execu-

The following abbreviations are authorized for use on field maps and sketches. When these words are used they must be written in full or abbreviated as shown. The abbreviations must not be used for other words than those in the table. Words not in this table are not as a rule abbreviated.

abut.	abutment	P.O.	post office
B.S.	blacksmith shop	Pt.	point
bot	bottom	Q.	quarry
Cr.	creek	q.p.	queen post
cul.	culvert	R.	river
E.	east	R.H.	round house
f	fordable	R.R.	railroad
gir	girder	S.	south
G.M.	grist mill	s.	steel
i.	iron	S.H.	school house
I.	island	S.M.	saw mill
Jc.	junction	Sta.	station
k.p.	king post	st.	stone
L.	lake	str.	stream
Mt.	mountain	trea.	trestle
N.	north	tr.	truss
n.f.	not fordable	W.T.	water tank
p.	pier	W.W.	water works
pk.	plank	W.	west
		w.	wood

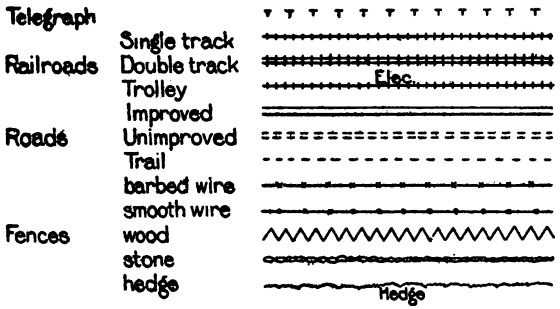


Fig. 144

*The sign for hedge given above is not as satisfactory as that shown in figure 147, p. 284, along the west edge of the sketch. The symbols for wire fences along roads should be placed on the lines used to mark the roads.

tion will often be secured by printing in small capitals the name of the growth in a given enclosure, as CORN, WHEAT, CULT. (for cultivated). In the same manner, with marginal notes and simple drawings, the character and condition of roads, ferries, bridg-

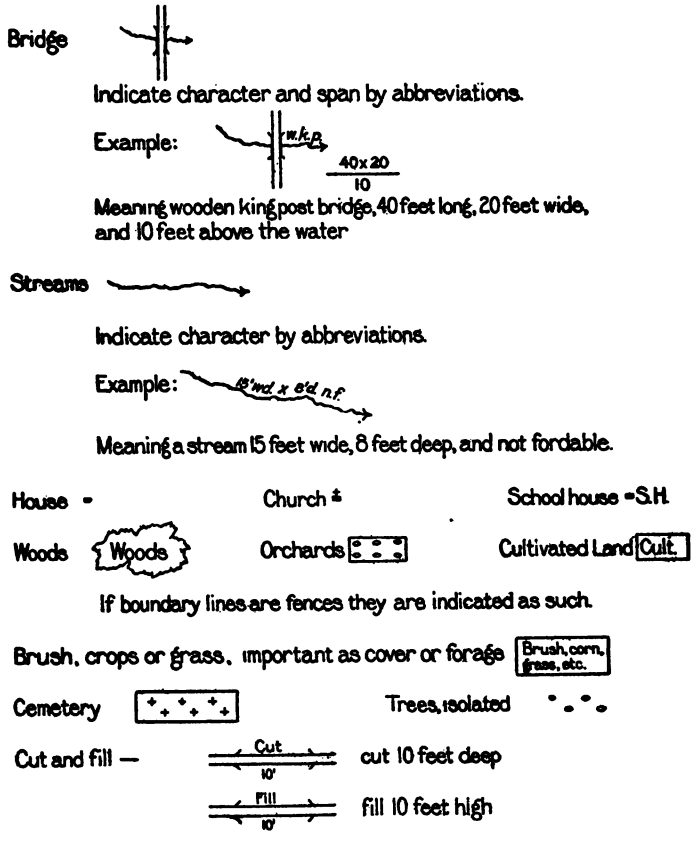


Fig. 145

All lettering on Position, Road and Place Sketches, except names of streams and roads, should be made so as to be read facing north. The lettering on Outpost sketches is to be read facing toward the enemy.

es, fords, buildings, etc., should be described; the sketch should be amplified by a *Reconnaissance Report* of the terrain, where conditions make it necessary, see par. 312. Points from which exceptionally extended views are obtainable should be marked in the margin, see reference to *d*, figure 143.

Prominent ridges, commanding positions, church spires, towns, etc., when visible, should have their direction marked by an arrow, with their approximate distance marked on it (see figure 143, to Soldiers' Home from *C*) even when several miles distant.

263. Sketches should be made on *tracing paper*, in firm pencil lines using a soft black pencil (HB), so that blue prints may be made directly from the sketch without the waste of time and labor of tracing. Since a number of copies of almost every military sketch must be made in the shortest possible time, they should never be finished on heavy drawing paper (except in the early practice work) nor in colors, unless copies of the original are not desired. In combined sketching, the work of all the sketchers should be uniform as to heaviness of lines and size of conventional signs. In case colors are used, the following system should be followed: Yellow for roads; green for trees; blue for water; red for stone structures; brown for contours and wooden structures. On the finished sketch, as intended for issue (whether blue print or original drawing), colors may be used with added clearness.

264. In making a military sketch the important considerations are *clearness, accuracy* sufficient for all military requirements, *simplicity* and the *completed sketch* in the time available.

Only details of military importance should be shown. Objects which are valuable from a tactical standpoint should be constantly kept in mind. It is of far greater importance to show location, shape and character of a wooded area by drawing its outline of conventional signs, within which is written its character, than to carefully fill up an area of incorrect size and shape with symbols for woods. Information of a wide dead space formed by a convex slope in front of a proposed defensive line is more important to the commander than the exact height of the position; therefore care should be used in spacing contours to show the ground as it really exists.

Under service conditions, the *importance of finishing the entire assigned area* in the allotted time can hardly be overestimated; but in learning to sketch, accuracy and clearness should be the only considerations. The sketcher should, therefore, in his early sketches, *measure every distance, slope* and *elevation,* after making in each case careful estimates; and he should only begin to depend on his estimates when positive that they are sufficiently accurate.

Distances to individual points off the main control lines (traverse or triangulation) should not be in error more than fifteen per cent; plainly visible

slopes should be correct to within one degree; differences of elevation, within one contour at distances up to five hundred yards from the traverse. In case the sketcher has had a course of surveying with precise instruments as described in *Part II*, he should be able, on its completion, to estimate distances, slopes, and elevations so accurately that he may dispense with many of the measurements to points off the main control lines after his fourth or fifth sketch. It is well for the sketcher to bear in mind that *on the principal control lines accuracy is of first importance*, but in locating any single point from which no other points are determined, its general position relative to the remainder of the sketch is sufficient. Rapidity is gained at the expense of accuracy in some parts of the work, and the difference between a fair and an excellent sketch depends much on the correct choice of the part of the sketch where accuracy is paramount and where it is unimportant. The balancing of accuracy and rapidity is taken up in detail under Position and Road Sketching; but *in the first sketches accuracy is everything*.

CLASSIFICATION OF MILITARY SKETCHES.

265. Military sketches are classified as *individual* or *combined* sketches. An individual sketch is of limited extent, executed by one person. A combined sketch is the result of the simultaneous work of a number of sketchers, so combined as to make a map covering a number of parallel roads (Combined Road Sketch), or an area extending across the

front of the command (Combined Position Sketch).

Military sketches are also classified according to their object or the method of their execution as:

1. *Area Sketches,* which are of three kinds (a) *Position,* (b) *Outpost,* (c) *Place Sketches.*

2. *Road Sketches.*

A *Position Sketch* is one of a military position, camp site, etc., made by a sketcher who has access to all parts of the area to be sketched.

An *Outpost Sketch,* as its name indicates, shows the military features of ground along the friendly outpost line and as far toward the hostile position as may be sketched from the rear of and along the line of observation.

A *Place Sketch* is one of an area, made by a sketcher from one point of observation. Such a sketch may cover ground in front of an outpost line, or it may serve to extend toward the enemy a position or road sketch from the farthest point which can be reached by the sketcher.

CHAPTER III.

METHODS OF SKETCHING.

266. *The Location of Critical Points.* Having learned the uses of military sketches and the details to be represented, it is next in order to take up the methods used for determining the location of the necessary critical points, around which the features themselves are sketched.*

Every critical point desired must be determined: (1) *Horizontally,* that is its horizontal distance and its horizontal angle of direction (azimuth) from the north-south line must be found, with reference to a starting point, assumed or known; (2) *Vertically,* either by finding its difference of elevation directly or by determining this difference of elevation from the slope and distance to the desired point with reference to the known point. A beginner finds it much simpler to become thoroughly familiar with the making of horizontal locations, before attempting the vertical locations, from which contours showing the slope of the ground are determined. For this reason contouring is taken up after the description of plotting in the horizontal details; and the beginner should practice making horizontal traverses, and triangulations, and drawing

*A critical point is one at which there is an abrupt change of general slope, or an abrupt change of horizontal direction.

details such as roads, woods, buildings, streams, before he attempts a contoured sketch.

267. *The Horizontal Location of a Point may be determined either by*:

(1) *Traverse,* or
(2) *Intersection,* or
(3) *Resection,* or
(4) *Offset,* or
(5) *By estimation* of distance and measurement, or estimation, of direction.

268. 1. *The location of an unknown point,* as B, with respect to a known point, as A, *by traversing.*

The drawing board, figure 135, p. 245, is set up at A, figure 147, p. 284, and levelled as accurately as possible by eye. The board is then *oriented* by rotating it horizontally until the magnetic needle of the attached compass points north. At every station the board must have this same angular position, so that *every line on the sketch will always* be parallel to the corresponding line on the ground. Assuming a point *a* on the paper in such a position that the ground to be sketched will fall on the sheet, lay the ruler on the board and point it toward B all the while keeping the edge of the ruler on the point *a.* Draw an indefinite line along the ruler's edge from *a* toward *b.* Now walk to B, counting strides and keeping a record of them with a tally register, par. 229. With the scale of the sketcher's strides on the ruler, lay off the number of strides found from A to B and mark the point *b.* Other

points, as C, F, etc., would be located in the same manner.

269. 2. *The Location of an Unknown Point,* as K, with respect to two known and plotted points, as T and C, figure 147, *by intersection.*

Set up, level, and orient drawing board at T, by laying the ruler along the line *t c* and rotating the board horizontally until the ruler points exactly toward C. (This is called *orientation by back sight,* as opposed to that described at station A, which is *orientation with the needle.*

Lay the ruler on the board, sight and draw a ray toward K. This ray need not be drawn entirely up to *t,* but only for a short length at the estimated distance to scale of K from T. Now move to C, assumed to be already plotted on the sheet in *c,* and having set up, levelled and oriented by a back sight to T, sight toward K, as done from T. The intersection of these two rays locates K on the sheet at *k.* Having *c* and *k* thus located, they may be used in the same manner for determining other points by intersection. It is seen from the above that a point is located by intersection without the sketcher's going to that point. To locate a point by *resection* the board must be set up on the ground at the point whose position on the sketch is desired.

270. 3. *The Location of a Point by Resection.* 1st Method. Having given a direction line, as *c q* figure 147, p. 284, on which lies the desired point, and a plotted point, as *k,* outside of that line; to determine the position on the sketch of any point

on the line C Q, as Z: Set up, and level the board at Z, then orient by laying the ruler on *c q* and rotating the board until the ruler points at C. Clamp the board in this position. Pivot the ruler about a wax headed needle stuck at *k* and sight K. Draw a ray along the ruler and its intersection with the line *c q* locates Z on the sketch at *z*. This method is as accurate as the method of intersection because of the exact orientation secured by back sight on C.

2d Method. Having given two plotted points, as *t* and *c*, fig. 147, to determine the position on the sketch, *k*, of a point K on the ground. Set up, and level the table at K, orienting with the needle. Clamp the board. Pivot the alidade on *t*, at the same time sighting T, and draw a ray along the ruler toward your body at the estimated position of *k*. Similarly, pivot the alidade on *c* sighting C, drawing a ray until it cuts the one from *t* and this point of intersection is the required point *k*. *This method* is available as soon as two visible points are plotted, and *finds very frequent use in sketching in details around a point such as K, which is not to be used to extend the triangulation.* Both of these two methods are of great value in position sketching. The 3d and 4th Methods of resection, par. 155, *Part II*, may also be used, but they will only be advisable in rare instances.

271. 4. *The Location of Points by Offset.* This consists in measuring distances perpendicular to the traverse for locating details. For example, a winding road Z L might be located by sighting

from Z towards L and drawing the ray *z l*, figure 147. The distance from Z to L is then measured along the ray (or along the road itself) and the critical points 3, 4 and 5 located by offsets perpendicular to the ray. The most general use of this method is in locating details along a traverse where the offsets are made by estimation.

272. *Methods in detail of finding the elevation of an unknown point* D *from a known point* A, figure 148, p. 284, *and the location of contours on this line.*

1. *Measure the slope* from A to D with clinometer, or slope board, *and the horizontal distance* by traversing, intersection or resection. Plot to scale the distance found and apply the M. D. for this slope successively along the plotted length. The number of times the M. D. is applied, multiplied by the contour interval (V. I.) equals the difference of elevation between A and D. For example, suppose A, figure 148, is at elevation 800; distance *a* to *d* as plotted 2.5 inches; V. I.=10 feet; slope from A to D=+1½°. The M. D. for 1½° is found to be contained 5¾ times between *a* and *d*; 5¾×10=57.5 feet. D is therefore at elevation 800+57.5=857.5. Now looking at the ground along A D, you find it to be a slightly concave (hollowed out) slope north of the bridge and steeper near the top. There are to be placed in the space *a d* contours 800 (at *a*), 810, 820, etc. to 850; they would be spaced close together at the top and farther apart towards the bottom in order to give a true representation of the

slope. South of the bridge (1) the ground is level and consequently no contours appear here.

In rare cases only do the slopes of hills change so suddenly at any one point that the actual condition of slope can be shown by a mechanically exact interpolation of contours by the application of the scale of M. D.'s. above or below this point of change. Suppose, however, such a case does exist as shown between *x and e* at *y*, figure 143, p. 255. This condition could be shown only by reading the slope and measuring the distance from X to Y and from Y to E. *x y* and *y e* could then be plotted to scale and the 6 degree contours spaced uniformly along *x y*, using the scale of M. D.'s. This assumes that the point of change of slope Y on the ground can be exactly located, but in reality *there is always more or less uncertainty as to the exact point at which the change takes place.* Moreover, it is exceptional to find ground sloping exactly uniformly as X Y. The usual case is either a convex or concave slope, changing so gradually from point to point that the observer can not pick out the exact points of change, much less be able to mechanically show these points by contours. He can however represent by contours the general character of the slope accurately by contours properly spaced.

In the older text books a laborious method of contouring was prescribed in which the sketcher would pace along a slope to each point of change and plot the contours on these portions. This method is impossible for rapid sketching on account of

its slowness and is moreover inaccurate on account of the accumulation of errors due to frequent short readings to unimportant points.

In military sketching the essential feature sought in contouring is to convey to the reader of the sketch a correct representation of the ground as it appeared to the eye of the sketcher. The sketcher can only give this information by determining the difference of elevation between two definite points, at the top and bottom of the line, and then, knowing the number of contours required, *spacing them to show the variations of slope as they appear to him.* For this reason great stress has been laid on the necessity of acquiring by diligent practice the ability to estimate the map distance corresponding to each degree of slope usually met with.

2d Method—Measure the difference of elevation directly with the barometer, and space the contours required by this determined difference of elevation to show the actual slope of the ground.

Method of Contouring After Acquiring Skill in Estimating Distances, Elevations and Slopes.

273. 1. *Estimate the difference of elevation* between A and D, Fig. 148, and, *space the contours by eye.* Or the number of contour intervals between A and D may be estimated. In this case the number of contours, including the top and bottom ones, is one greater than the number of contour intervals.

When a Generally Uniform Slope Extends to the Limits of the Sketch.

274. 1. Read the *slope with a clinometer* or slope board, and with the scale of M. D.'s for the slope locate contours to the limits of the sketch without determining the elevation of any point on the line other than the one known.

2. *After skill in estimating is acquired,* estimate the slope and plot the contours with the scale of M. D.'s.

3. *After skill in plotting by estimation of the Map Distances corresponding to different slopes is acquired,* estimate the slope and space the contours by estimation.

THE EXECUTION OF A POSITION SKETCH IN DETAIL.

275. The instruments required by a beginner are preferably the following, but others may be used as noted below:

1. *Drawing Board with Declinator on Tripod,* figure 135, p. 241, see par. 241.

2. *Loose Ruler,* figure 137, with scales described par. 243, figure 136, p. 242.

3. *Service Clinometer,* figure 138, see par. 244, carried in upper right blouse pocket, and secured to it by a strong cord.

4. *Tally Register,* par. 229, attached by a string and carried in the left trousers pocket.

5. *Equipped Pencil, Knife and Ruler Holder,* figure 146. This may be made of heavy canvas sewed over a board frame. It should be secured to

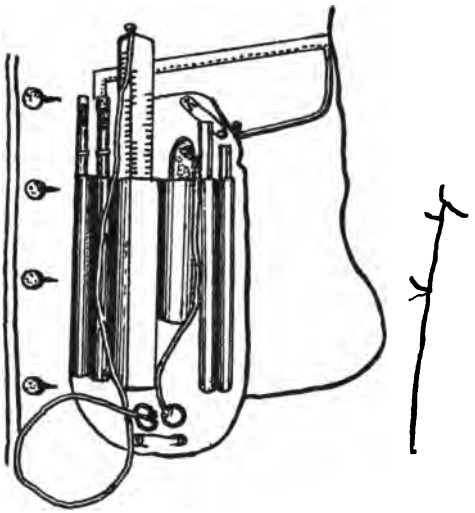


Fig. 146

the sketcher's blouse on his left breast. The knife and ruler may well be fastened to the holder as shown, to prevent their being lost.

It will be of great value to the sketcher to have *one definite place for each article of equipment, and one well fixed method of performing each operation* in sketching so that there may be no hesitation in the work. Sketching utensils have a remarkable habit of losing themselves, unless they are tied to something or placed in some particular receptacle after each use. Pencils of different degrees of hardness should be marked clearly so as to avoid delay in taking out the proper one. The points should be protected by rubbed-tipped brass covers.

6. *A Soft Rubber Eraser* may be carried attached to a cord around the sketcher's neck.

7. *Field Glasses* are of considerable value in picking out distant points for intersection or resection, and for studying the details of ground forms at a distance. If used they should be carried on a waist belt. It is well to have a reserve of at least one each, of the ruler, rubber eraser, pencils and a sheet of celluloid for use in rain, all carried in a haversack, or dispatch case.

METHODS OF WORK.

276. The detailed methods of using the instruments have been given heretofore. A description will first be given of the methods of locating the horizontal details only, followed by the methods of contouring the area. It will be best for the beginner to pursue this system in his first two or three sketches, of locating and drawing in roads, streams, woods and all other horizontal details, and on this frame-work later locating his contours. To do both simultaneously will at first prove confusing because of the large number of matters to be kept in view. However, both horizontal details and contours can be carried on together from the start if so desired, but no effort should be made to do rapid work until the methods are familiar.

1. *Select and Traverse a Base Line.**

2. *Locate a Series of Critical Points* over the area by Intersection.

3. *Fill in the detail,* par. 260, *in the vicinity of these triangulation points,* see figures 144 and 145,

*It is assumed that you have previously determined your length of stride and have constructed a scale of strides, par. 229.

p. 260, for conventional signs prescribed by Field Service Regulations for sketches.

4. Fill in detail around other important points located by Resection.

5. Fill in all other required details by Traverse to all necessary points not visible from the Intersection or Resection Stations.

277. The *Base* is a line in the area to be sketched, as centrally located as possible, and from one-fourth to two miles long depending on the size of the area. It should be long enough so that lines drawn from its ends to locate necessary critical points by intersection, will intersect at angles between 30° and 120° to give accurate locations. Its length should generally be not less than one-third as long as the greatest dimension of the area to avoid having to extend small triangles too great a distance from the original base. Often a shorter base can be used if located in the middle of the area than if near one end, because the extension of intersection points would be made on both sides of the base.

The ends of the base should be marked by some well defined objects, such as telegraph poles, trees, corners of buildings, or even temporary poles, branches of trees, weeds, etc., set up by the sketcher so that they may be seen by him from a distance in sighting back on these points. If an object such as a telegraph pole is chosen as an end of the base, so that the board cannot be set up exactly under the point which will later be used to sight back on,

the sketcher orients his board near the pole and draws a short ray toward it, pacing and plotting its distance, to scale, measured from the board's location. The pole is thus located accurately on the sheet for back sighting purposes though the board is never set up exactly at that point. This method would also be useful where local attraction is known to exist at the desired station point, as in the vicinity of poles carrying heavy electric currents.

An extensive view of the area should be possible from the ends and from several intermediate points of the base. If the area is intersected by ridges and valleys, the best base is usually to be found along a central ridge(because from this position the two adjacent valleys are visible as far as the tops of the two ridges beyond. If the ridges are very flat topped and convex in shape, so as to prevent a good view into the two adjoining valleys, it may be advisable to locate the base perpendicular to the axes of the ridges, though the pacing up and down hill is less accurate. A road or railway crossing the area more or less perpendicular to the ridges and valleys, gives a very good base. The accuracy of pacing the base is of great importance, because errors made in this part of the work extend and accumulate over the entire area. To secure this accuracy, the base should, where possible, be generally level and lie over firm soil such as roads, trails, railroads or pasture land.

In figure 147, p. 284, the broken base A B C, along an edge and extending across the middle, is

chosen because of the good view obtainable, the good pacing possible along the road and railroad, and the central location afforded. It is started from A because this happens to be the first point of the area reached in going to work; and also because sights to B and to D determine two boundaries of the area. The length of this base is such that triangles with suitable angles of intersection are possible as shown in figure 147. The telegraph poles along B C give good points to resect on. In figure 143, p. 255, the base used was A, B, C, E, because from this line a better view over the area was possible than from any base in the center of the area.

278. *To Traverse the Base.* Set up, level and orient the board at one end of the base, A, figure 147. Draw a meridian on the edge of the sheet parallel to the declinator trough's edge. It is well to form the habit of placing the sheet on the board with an edge parallel to the N-S line of the declinator, so that you can always use this edge and the other parallel edge as meridians. Assume a point *a* on the sheet corresponding to A on the ground. In this sketch a telegraph pole is selected, and the corresponding point on the sketch is taken near the southeast corner of the sheet because the area lies to the north and west.

From the first station, prominent easily distinguishable points are sighted, such as hill tops, stream junctions, stream heads, etc., to begin the

location of these critical points, by intersection.* In figure 147 sight along road A B and A D and toward the stream junction Y, drawing light indefinite lines (rays) with 4 H pencil towards these points. Traverse from A, noting the number of strides recorded on the tally register opposite the house and the wire fence north of road A B but without halting until B is reached.

279. *Procedure at B.* Halt, set up, and orient the board by a back sight on A. With the scale of strides on ruler, scale off the distance from A to B also from A to house and to wire fence. Now, before the orientation has been disturbed by the work done on the board, pick out with your field glasses the next station, C, an elm tree on top of a railway cut, sight and draw a ray in its direction. Next draw in with H (or HB) pencil the road A B, the house at its estimated distance from the road and sketch the wire fence in the direction it was observed to lie. Take a careful sight at the chimney of Flint House, which is a prominent point visible

*It is well to have a systematic order of taking the intersection sights from any station, as for instance, from right to left across the front, so that no desired object will be overlooked by a haphazard method. These objects sighted should also be recorded systematically so that the different rays will not be confused when the time comes to finish the intersections. This is best accomplished by placing a serial number exactly on each ray from a station; and on the edge of the sheet, placing a tabulated list of these sights for each station as follows:

From Station A—
Sights:
1. Road A D.
2. Wire fence corner.
3. Stream junction.

from all parts of the area and will be useful as a point to resect on. Traverse toward C, halting at X. On the top of the bank here, set up, orient by a back sight and take the following observations: Flint chimney; bridge north of A; hill top at road A D north of this bridge (north limit of sketch); directly up the ravine line north of X; to the stream junction just east of the railroad track; to Y. Now sketch the Flint House and barn; the wire fence east of X running toward the north and its branch to the road A D; the stream from Y to road A D and trees along it; the three small ravine lines joining this part of the main stream from the south; telegraph line along the railroad right of way toward B; the orchards at Flint and at A.

280. *Traverse toward C,* noting the recorded strides at G and the ridge north of it. Halt and set up at T (south end of bridge). Scale off T, G, etc., from B. Sight on K and along the main stream to the east and west, also up the draw east of C; to intersection of roads A B and L Z also ridge top at M; sketch in the main stream east to Y and the branch ravine lines on this section; the trees and stream banks (shown by hachures or brief statement of condition), and the railroad track back to X. M is at the intersection of the north edge of road A B with the ridge top, and its map representation *m* is at the intersection of *t m* and *a b* prolonged. In the same way, later on, from station K the other critical points (ridges and valleys in this case) on the road are located by drawing rays to intersection

with *a b* prolonged. It is well here to call attention to the importance of locating all straight lines in the area such as the boundary fence of this road, wire fences, hedges, straight line of telephone poles, etc., because they furnish a valuable means of locating any points on them by intersection as was done in the location of M from T.

Continue the traverse to C, noting number of strides at wire fence corner without halting. At C halt, set up and draw in detail between C and T, also the wire fence east to D. The east end of this fence was found from X by intersection on the line *a d* from the 1st station, A.

It will be observed that you have now located all the horizontal details east of your Base without traversing any of this area, with a great resultant saving of time. All of this work has been done *by traversing* along the Base and locating the necessary critical points east of it *by intersection.* Sight to K to complete its location, also to the point where road Z L crosses stream, and the ravine line junction with the main stream south of C.

281. *Resection at Z.* It is now necessary to carry the work forward from C, but on hill Z there is no definite point which could be located with certainty from T and C by intersection. You therefore look for something to sight on, so as to establish a direction line on which you can place yourself after reaching hill Z. You observe that you can look exactly up a small ravine toward a tree at Q, so draw a ray in this direction. (A well de-

fined fence corner, bush, etc., would be equally as satisfactory as the ravine to sight on.) Move at once to the top of hill Z and place yourself on the direction line from C, at the most convenient point of the hill for observing the ground (on road Z L). Set up and locate your position by resection on K, and sight the stream junction toward K, also the draw S by estimating its number of yards from Z. Sight along the general direction of road L Z. You observe that a hedge fence extends along the western boundary through Q. You have not located this hedge, but observe that you will be able to do so by intersection from Z and K on two of its points, Q and R. Therefore, sight from Z at these two points on the hedge, then move to K and complete their location. Draw in the hedge R Q, thus locating all the critical points sighted on this line from E. From K locate the critical points on road A B as described above. Draw in all the water course and water shed lines west of the railroad, for which sufficient critical points are now known; also the other details such as roads, trees, houses, wire fences, etc.

282. It will be observed that the horizontal details of this sketch have been put in by use of the methods of *traversing, offsets* (along the base), *intersection* (*d, m, k, q, etc.*), and *resection* (z). S was located by *estimation,* since it was only about 200 yards from Z. A small amount of estimating has been done in getting the directions of ravines and of water sheds of ridges, between the two or

more points located on them. Gradually you can increase the amount of freehand sketching based on estimation as you acquire skill from practice. The portions of the area located by resection, intersection or traverse will vary in amount for each particular sketch, depending on the nature of the ground, the amount of woods, etc., preventing good views.

It is evident that the work from a carefully paced base over fairly level ground is more accurate than if traverses were run all over the rough and steep parts of the area. Therefore, as much of the work is done by intersection and resection as possible, traversing (except along the base) being done only where desired critical points are hidden by woods, etc.

You will also observe that *all sketching of details has been done toward the rear*—that is, from the last located point back to others previously determined. This is a vital principle in all this work, that *no sketching should be done in front of the last located point.* (Except that local details may well be put in by estimation for 50 to 100 yards forward from each station.) There is with beginners a strong tendency to do this, especially in drawing contours, but such work will usually be incorrect and have to be erased, causing a waste of time and great confusion to the sketcher.

CONTOURING THE POSITION SKETCH.

283. Having thus completed the location of the horizontal details of the area, start in again at A

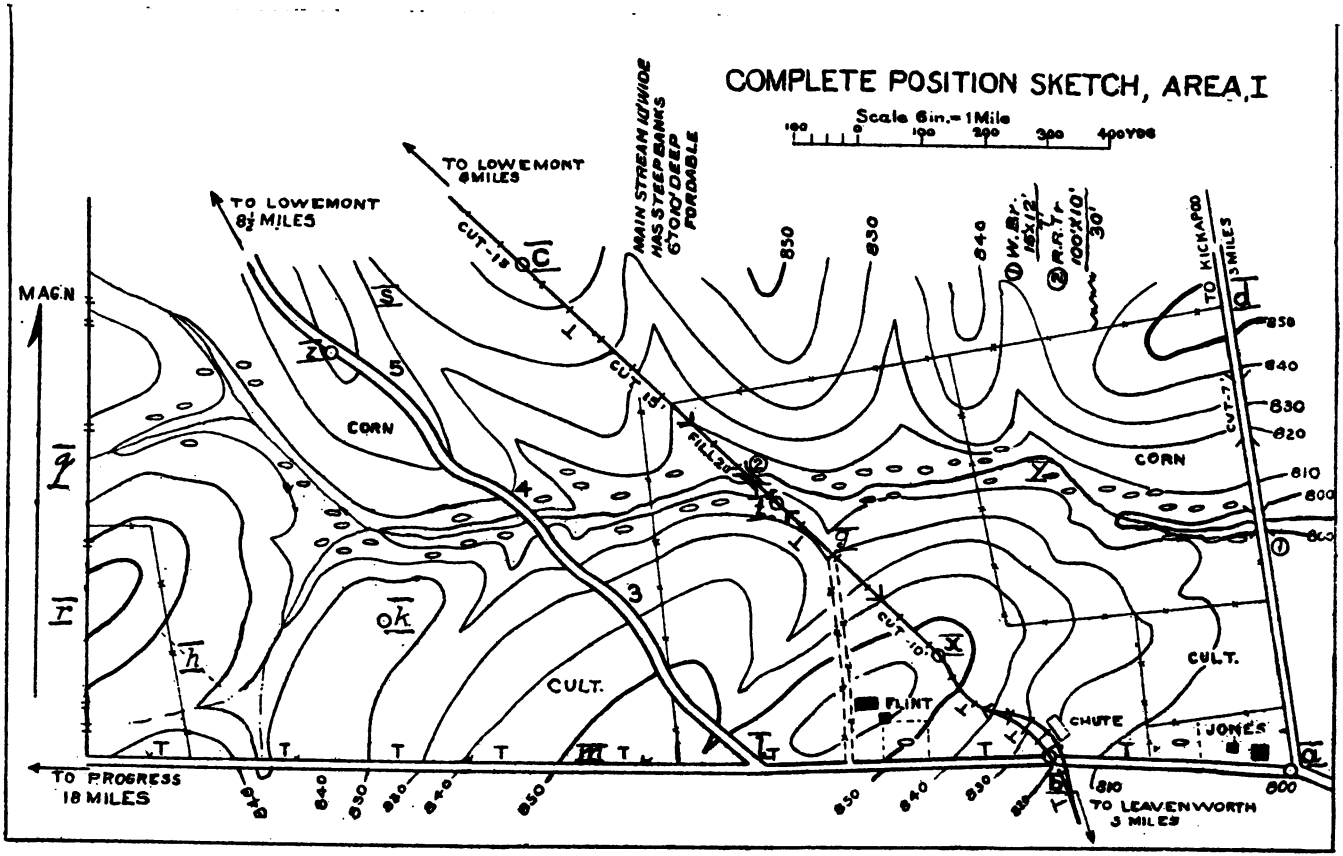


Fig. 148

to determine the vertical locations—that is, elevations, slopes, and the contours to represent the shape of the ground. Suppose A to be at elevation 800 feet above sea level. On the sketch you now have located the horizontal position of all stream lines, draws (water flow lines), and hill tops, figure 147, *From station A* read carefully the vertical angle ($+1\frac{1}{2}°$) to the top of hill D. Apply the M. D. scale on the ruler to *a d,* and you find that there are 5 contours required, see par. 272, between A and D, the 810, 820, 830, 840 and 850: but reading the angle to the bridge north of A, you find its value is zero degrees, or horizontal. Therefore all five of the contours fall beyond the bridge and you can see that the slope is gently concave. You therefore *space the contours accordingly to show this fact* as in the figure, 148.

284. *Procedure at B.* Next move to B and read the angle to A (—1°), and applying the M. D. scale, you find two contour intervals between A and B the ground is quite steep near B and flat near A. You therefore space the contours as shown in the figure. To verify your idea of how close together to space the 810 and 820 contours, read the slope from B to the foot of the hill. You find it to be (—3°) by applying the M. D. scale; this agrees with the spacing already estimated. While at B note the general slope of the road to the west for use in spacing contours along it later.

Next move to X, set up and read the slope to B (—3°), to Y (—3°), to G (—3°). Applica-

tion of the scale of M. D., shows that B (820) is $3\frac{3}{4}$ intervals below X. Hence X is at elevation 857. The slope from X to B is practically uniform and the contours are spaced as shown. Applying the M. D. scale, you find $5\frac{1}{2}$ intervals from *x* to *y*. This is a gently convex hill and the contours are drawn as shown. Since X is 7 feet above the 850 contour, this is placed nearly one M. D. distant from *x*; and for a similar reason the 810 contour falls a short distance south of the stream. Join up the contours between the line *x y* and *x b a*, with due regard to intermediate slopes of the ground. Also, having determined the elevation of Y (805), you are able to draw in the contours on the ridge *y d* by examining its slope through your field glasses. Extend these contours to join those already located south of *d*, keeping in mind the variation of the ground and remembering the small map distance corresponding to small inequalities noted.

285. *Estimation.* Instead of reading the slope to the top of Flint hill you observe that it is only 5 or 6 feet higher than X, and hence only one contour (860) goes in; this falls about 50 yards from X, and is drawn in by eye as shown. You also draw in those required between the 850 contour and B along the road.

Now move to T and stop a moment to read the slope up ravine G, without setting up the Board; likewise at the ridge just north of it. Continue to T, set up the Board here and put in contours between X and ravine G, and on ridge to M.

Read the slope from T to X and find the elevation of T as heretofore described for B and X. From T read the slopes to ridge and valley points on the fence running east to D, and draw in the contours down to the main stream.

Proceed to C; read the vertical angle to X, to K and to stream junctions south of C, locating contours as already explained. Continue over the entire area, always remembering to locate contours in rear of the last known point, and not to leave a station until all the details up to that point are drawn in.

286. *Locating Horizontal Details and Contours Simultaneously*: Having finished locating the contours over your first area, go back again to A and carry on both horizontal and vertical determinations together. This can now be readily done simultaneously on the area you have studied by the two separate operations. For example, at A, set up, orient with the needle, draw a meridian, sight D, B, Y, and fence corner; read vertical angle to D draw in road A D. Move to B, set up, orient by back sight on A, plot *b,* house and wire fence; sight C; draw in road A B (note slight curve), cattle chute and switch; sight Flint House chimney. Now read the vertical angle to A and contour *a b,* and so on continue the work, being careful to follow a regular order in the different steps. It is well to keep in mind, however, that there are really two independent sets of determinations being made at each station, one horizontal

the other vertical, as this helps to systematize the work.

287. *As you acquire skill in sketching, in estimating and tracing contours, you will constantly require fewer and fewer controlling located points, such as B, X, Y etc., with a corresponding gain of speed and accuracy of representation.*

EXECUTION OF OUTPOST SKETCHES.

288. *The Making of an Outpost Sketch* differs from that of a position sketch in nothing except that in the former the sketcher cannot advance beyond the line of observation, but must show the ground from one-half to two miles in front of this line toward the enemy. Consequently, he will be limited to locations by traverse along the base and intersections from stations on the base to determine critical points over the area out in front. The method of resection is not usually applicable because this requires that the sketcher go to the point located. *The Base* might, however, be located *some distance in rear of the outpost line,* (if the sketch were being made under fire of the enemy, to avoid exposure in traversing along the line of observation); and from this retired base critical points could be located on the line of observation by intersection or resection. The sketcher would then approach these located points by creeping up from the rear, orient his board flat on the ground and sight necessary critical points over the foreground. The information to be represent-

ed on the outpost sketch is the same as is shown on a position sketch and on the same scale.

There will often be portions of the base from which good views to the front are not possible. It is therefore necessary to study the ground most carefully from each base station, in order that critical points may be selected which can be seen from at least one other point located along the base, so as to give good intersection angles. For the critical points only a short distance in front, observations must be taken from points correspondingly near each other along the base. To locate critical points far to the front, the extreme ends of the base would probably be used as stations from which to intersect.

It will often be impossible to see more than a small part of one hill lying beyond another, or the lower part of a small ravine may be seen, of which the upper part lies beyond a hill. If, as is often the case, a good estimate can be made of the nature of the hidden area, judging from the visible parts, then the concealed portions should be drawn in broken lines to indicate the method of location used.

Field Glasses are of great assistance in this work in picking out definite objects to intersect on, and in discovering folds of the ground not visible to the naked eye. If two ridges lie generally parallel to the front and at some distance from the base, it will often be possible to discover the farther one only by the line of different light made by the nearer one against its side slope.

CHAPTER IV.

THE EXECUTION OF A ROAD SKETCH IN DETAIL.

289. The instruments required by a beginner in road sketching are preferably as follows, but others may be used as noted below:

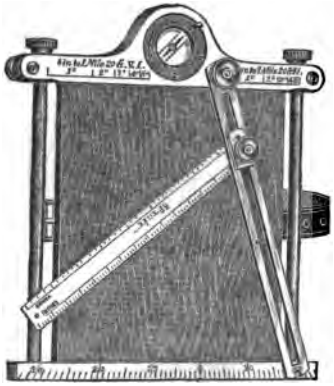


Fig. 149

1. *Drawing Board,* with declinator, on folded tripod, figure 151, p. 290, or Cavalry Sketching Case figure 149.

2. *Loose Ruler,* figure 137, with scales shown, figure 136, p. 242.

3. *Service Clinometer,* figure 138 (see par. 246) carried in upper right breast pocket, secured to it by a strong cord.

4. *An Equipped Pencil, Knife and Ruler Holder,* figure 146, p. 273.

5. *Soft Rubber Eraser.*

6. *Stop Watch and Note Pad,* figure 150 (for mounted work).

METHOD OF WORK, DISMOUNTED.

290. *A Road Sketch* is *normally made mounted* on account of the rapidity of work thereby secured. It is well, however, for the beginner to make

his first one or two sketches dismounted to become accustomed to the three inch scale and twenty foot contours, before attempting to manage a horse in addition to the work of sketching. There may be occasions too when a horse is not available, so that a sketcher should be able to work with equal facility either mounted or dismounted.

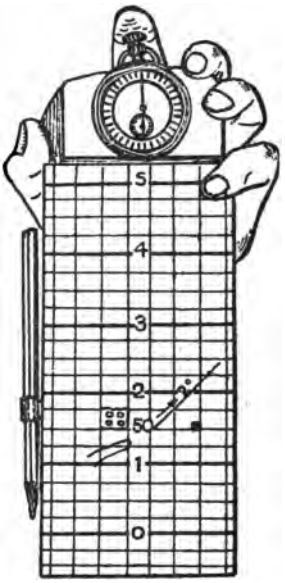


Fig. 150

The method previously given for traversing the base, A B C figure 147, in making a position sketch is, in general, identical with that used in a dismounted road sketch, except that intersection locations are not usually required at more than four hundred or five hundred yards from the road, and no resection work is usually possible. A large part of the work is done by traversing the road and estimating offsets. After the first one or two sketches, the sketcher will not usually leave the road, except to go to the top of some crest a few yards distant to get an extended view. Details will be limited to four hundred yards from the road, except for prominent positions, etc.

There will often be areas within the 400 yard limit, which are not visible from points directly opposite them on the road. These areas, however,

may usually be seen from some point along the road before or after passing opposite them.

The drawing board may be used in road sketching, with or without the tripod. If the tripod is used in mounted work it should be folded to a single length, figure 151, as it thus furnishes a firm support and also a convenient hand-hold for carrying the board on horse back. More accurate work can be done by using the tripod in this way, without loss of time, than can be done by holding the board in the hands. Some good sketchers use a board with wrist strap, and for important

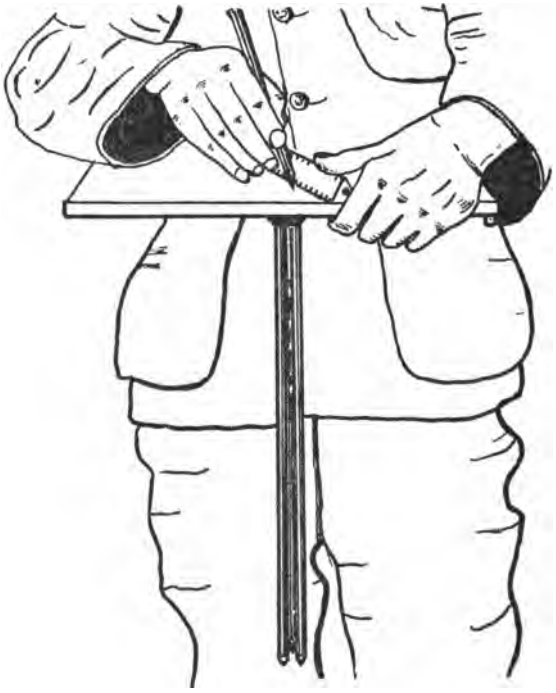


Fig. 151

sights place it on the ground and lie down prone on the opposite side of the board from the point sighted.

In unimportant sights and in locating details around any station, even when the tripod is attached, the board need not be set up on the ground but is held pressed against the breast, figure 151. The sight is taken by fixing the eye on the distant object and then glancing quickly down at the ruler and making the necessary adjustment of the ruler's direction. In practicing this method, you should use a board on tripod and check each sight by carefully looking along the ruler. Never sketch with the cord holding the board around your neck.

The method of using the Cavalry Sketching Case is identical in principal with that of the drawing board without a tripod. A sketcher having learned one of these instruments will have no difficulty in using the other.*

TO LOCATE HORIZONTAL DETAILS.

291. 1. *Orient the board,* par. 268, at station A, figure 152,† p. 302, holding it in front of your body, that is between you and the object sighted.

*The advantages of the Drawing Board over other forms of sketching cases:

1. Its larger size gives sufficient area for two miles of position sketch in both directions; and about twelve miles of road sketch by running three traverses across the sheet. It is equally as portable as the Roller Sketching Cases.

2. Being practically square, the full length of the board is available, no matter what the direction of the traverse may be,

†From sketch made by Captain A. W. Bjornstad, 28th Infantry, in the Army School of the Line.

By glancing every moment or two at the declinator (or compass) see that the needle remains in the meridian. With the declinator, the orientation is effected most rapidly and is free from possible errors of needle reading. The sides of the declinator trough check the vibrations of the needle, and the orientation is correct when the needle

without the necessity of orienting this board in some special position. The Cavalry Case and all similar ones have such a small drawing surface that it is necessary to orient the sketching case so that the traverse extends in the direction of the rollers. This direction of the road to be sketched will often not be known, thus causing the sketch to run off the paper frequently, with resulting delay and annoyance.

3. It has been found of great value in rapid sketching to have **flat sheets**, so that when the parts of the sketch are to be pasted together, the sheets will lie out flat without twisting and curling up, due to being on rollers.

4. **The attached ruler of the cavalry case** is a time consuming device, and should be removed and a loose ruler substituted. Simplicity of each article of equipment is absolutely essential to rapidity of work.

5. **The note book and compass method has no advantage** over the drawing board method and is much slower, because the taking of intelligible notes from compass readings requires as much time as the making of a complete sketch with the board. The notes then require as much time to plot as was used in taking them. The errors mentioned in paragraph 240 are more liable to occur in this method and, in addition, other mistakes and omissions occur because the ground is not visible at the time of plotting. The reason often given for this method is that it can be used in the rain. The taking of notes in the rain is almost as difficult as sketching, and by use of celluloid with a ground surface, a pencil sketch can be made in the rain. This celluloid takes pencil lines readily even when it is perfectly wet. These lines may be readily erased with a soft rubber, but are not erased or smudged due to rubbing of hand and ruler in sketching. This celluloid is more transparent than tracing paper and allows blue prints to be made from the pencil sketches without retracing.

6. The Drawing Board equipment is easily improvised using a box top for the board and any straight stick for the ruler. The compass and tripod are not absolutely essential.

strikes both sides of the trough with equal force. This can be easily determined by observation, and by listening to the click of the needle against the sides. To orient rapidly, note which side of the trough the north end of the needle (marked N) rests against, rotate the board continuously in this direction until the needle leaves this side and *swings equally on both sides of the meridian.* If the needle is very sensitive it will not come to rest quickly but you need not wait for this if you observe the above rule as to equality of swing. Remember to *see that the orientation is correct during all important sights,* especially along the main traverse. The needle of the Cavalry Case being very short and often sluggish, may appear to be more easily kept on the meridian than a longer needle. This does not mean that the orientation thus secured is better, but quite the contrary.

292. 2. *Take a forward sight along the traverse* toward B. Next sight the prominent critical points within three hundred or four hundred yards of A, figure 152, for example the directions of road to the north, and southwest up the stream south of A B.

In making this sketch, you observe that the road A B is generally straight until the high hill at E is reached; you can therefore afford to spend a little extra time on this forward sight along the traverse, because of the amount of sketching depending on it and the consequent necessity for accuracy. Traverse to station B, noting the strides re-

corded on the tally register opposite the wire fence and railroad track. You should be able by this time to record your strides so automatically, see par. 229, that *your entire attention can be given to the study of the details to be put in.* You observe that the stream north of the road A B runs parallel to it at about two hundred and fifty yards distance. At first you would verify this estimate by halting at the railroad crossing and taking an intersection sight on the bridge north of A. You also observe in passing that the wire fence, noted before, runs parallel to the road north from A. At the railroad you observe that the track is perpendicular to the road on the south, and curves off to the northwest into a cut ten feet deep and one hundred and fifty yards long.

293. *Methods at B.* Having reached B, orient the board, plot in the roads branching from A and all details between A and B, first scaling off the distance to the wire fence, railroad track and B. The best method of doing this sketching in of details is to sit on the ground facing toward A, and draw in all details free hand, except roads and fences. The board need not be exactly oriented for sketching in details. With a little practice parallel lines for road boundaries can be easily drawn with the ruler. First draw the further line, then slip the ruler toward you and draw the nearer one. This allows you to keep the one first drawn in view and enables you to get the two parallel.

294. The conventional signs for roads, trees, houses, etc., should be drawn about the size of those in the figure. Telephone and telegraph lines are sufficiently indicated by conventional signs *at wide intervals* as shown. Information concerning bridges, may be shown as indicated in the sketch for the railroad bridge,* figure 152, p. 302, (W. T. $\frac{15}{100\times10}$), meaning wood truss, 100 feet long, 10 feet wide, 15 feet high; or it may be tabulated on an edge of a sheet as for bridge (1) and (2), figure 147, p. 284.

295. Having located the details from B to A, sight the stream junction southeast of B, to complete its location. Continue the traverse in the same manner to E, halting from time to time to *plot the details in rear of the point reached.* At E orient the board carefully, sight along the new direction of the road to the crossing F, and toward the prominent hill top X. (If you are using the short tripod your orientations should be by back sight; if you are holding the board in your hands, the orientation will be by compass). Take a sight to G to serve as a check on the traverse to that point by way of F. Where a stretch of road has a number of small bends, but is generally straight, these *accurate check sights far to the front are valuable* in keeping the correct direction, the small bends being drawn in by estimated offsets at the number of strides noted in passing them. To take

*According to F. S. R. Signs, p. 260, this should be thus: (w. tr. $\frac{100\times10}{15}$).

a large number of short sights of one hundred and two hundred yards tends to accumulate errors. *In a long traverse in one generally straight line* as from A to E, *strides should be recorded continuously* for the entire distance, to avoid confusing the point from which the plotting is done and the accumulation of plotting errors.

Now traverse to the crossing F, without halting at Kennedy, but noting the number of strides to the road bend, to the house, and to both ends of orchard. Houses at cross roads (or other prominent points) should be located in their correct position, and the names of owners should be shown, for use as landmarks in the designation of routes of march, etc.

Having arrived at F, you would continue the sketch in the same manner as already explained.

CONTOURING THE ROAD SKETCH.

296. Having located the horizontal details of the sketch, you should go back over the road putting in contours. (It is assumed here, for purposes of description, that you start in again at A to put in contours.) Looking north from A you observe that the ground rises only two or three feet above your present position and falls below your level (800) at the stream. You verify this by noting that the zero reading of the clinometer strikes the ground just beyond the bridge. Orient the board and draw the 800 contour up both sides of the stream to the point estimated as at your present elevation. Also draw in the 800 contour

on both sides of the stream in the immediate vicinity of A.

Move to B, and read the vertical angle to A (—1½°), being careful to sight a point as high above the ground at A as your eye is above B. Apply your 1½° M. D. and find it contained two and a half times between B and A, or B is at elevation 850. The 820 and 840 contours must be put in between the two stations. You observe that the ground near A is flat with a rise of about three degrees near the railroad track, so space the contour to show this. In all your road sketching be sure that the contours (especially on every steep slope) *show accurately the slope of the steepest part of the road* to convey to the commander correct information of the heaviest slopes over which the trains must pass. The spacing of contours on the flatter portions is less important, but must show the character of the slope—concave, uniform or convex.

Now read the slope to the stream junction to the southeast (—3½°). Remembering that you are at 850 elevation, and noting that the slope is uniform, you place the 840 contour about ½ a full M. D. from B.

You now observe that the Flint House is only about 10 feet above you, and consequently that there can only be the 860 contour around this hilltop as shown. To verify this you read the angle to the highest point of the hill and find a +2° slope just west of the house. Application of M. D. scale shows the hilltop is 15 feet above B or 865.

You now draw in the contours on both sides of the road between B and A as shown, spacing them to show correctly the ground forms and slopes. The contours should be numbered as soon as finished.

297. The difficulties which you encounter at this station B are exactly those encountered at all subsequent stations throughout the work, but what seem to be insurmountable obstacles to you at first, will gradually become perfectly simple. And this skill will be acquired quickly or slowly, *depending on how carefully you analyze the essential elements of ground forms around each station* in the early stages of the work. The beginner arriving at B looks around him hopelessly trying to pick out the important points to be considered; but as he grows accustomed to the work he will grasp at a glance the critical points to be located and the details to be shown. *Constant study in converting ground distance to map equivalent, and in plotting the location of the contours around the station* is most valuable practice. You now look ahead and observe the slope of the ground on both sides of the road, and note that the road falls gently about 12 feet at the first draw, then rises nearly to the height of B opposite Mottin. You also observe that there is a ridge line (shown dotted in the figure) extending along the north side of the road from Flint to Mottin, where it crosses through the grove, and that consequently the 840 contour must be about equal distance on each side of this ridge line, since the slopes of the hill near its top seem uniform.

298. *Carrying Elevations Forward.*—From B you can see the road some distance forward; therefore lie down with your eye near the level of the road and take a zero clinometer reading forward. This line of sight strikes the ground about 15 feet below the top and some distance east of the ridge at Hund, and the trees at Mottin about 4 feet above the road. Note this point near Hund for later reference as at 850 elevation. Note carefully the shape of the ground forward, especially the relative heights of the points where ravines cross the road. The horizontal locations of these points have already been determined in your previous work over this course to locate horizontal details. The question often comes up as to the necessity of taking the vertical angles to each small depression such as H and K, where you can readily see that no contour, or at most but one, is to be put in. Such observations are impracticable and unnecessary and would give less accurate results than a direct estimate of the height of these points on account of the short distance involved.

299. Now move to the high point north of Mottin, and looking back observe that B seems a little higher than your position, so you read the angle and find it about $(+\frac{1}{4}°)$. Being curious to see how this agrees with your estimate from B, (see above) you apply the scale of M. D.'s. and find the difference about 6 feet. In order that direct estimates of differences of elevation may agree with those found by clinometer reading and scale of M.

D.'s., you must have determined your stride scale correctly; and your clinometer must be in adjustment, or its error known.

Now draw in the contours on both sides of the road back to B, making a careful estimate of their position, and noting that the ridge is flat topped and convex shaped.

You already have a reference point of elevation located; so proceed to the top of Hund ridge, studying the ground and noting the number of strides opposite the selected reference point. Estimate the difference of elevation between your position and the reference point (15 feet) and verify it by a slope reading and application of M. D. Continue the work of contouring in this manner throughout the sketch, slowly and with many measurements at first; but gradually depending more on estimates of slopes, elevations and contour positions, as you acquire skill in analyzing ground forms. For instance, from B you should have made an estimate of its height above A to see how it checked with your other determination; similarly the height of Hund ridge should have been estimated from B.

ROAD SKETCH MOUNTED.

300. After you have made about two dismounted sketches, it is well to begin mounted work. The general methods involved are identical with those used in the dismounted work. The greatest difference arises due to the *necessity for controlling the horse,* in the *greater training of the eye re-*

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quired to fix in mind the ground forms while moving rapidly from one station to another, and the *necessity for a more systematic method of work* to secure rapidity. When mounted you have a considerably better position for observation of the ground on account of your height above the surrounding country. You should *do all plotting dismounted* because of the greater rapidity and accuracy of working in this position. The time required to ride between stations at a trot and to dismount and mount at each is small compared with that required for the actual work of sketching. *Every step of the work should be done according to a fixed system.* For instance you should work out one definite method of carrying your board; one certain position to take for sketching immediately on dismounting at each station; a method of keeping time notes, and of keeping the horse at a uniform gait, a definite order of plotting distances, details, and contours.

301. *Use of an Assistant.* If you have an assistant, decide whether he is to keep the uniform rate; to learn the names of owner's of houses; to read slopes; to call your attention to details such as orchards, windmills, telegraph lines, cross roads, etc. Each man must work out the system best suited to his own needs, but the following suggestions are offered (assuming that you have no assistant) for carrying pencils, clinometer, etc.:

302. *To Move Between Stations.* On starting from a station *stop the needle,* swing the board

over your back, figure 153, and grasp the reins in the right hand. Best control of the horse can be secured by tying a knot in the reins in front of the pommel, and grasping this knot. The folded tripod does not interfere with your freedom of action in taking notes. The left elbow is supported by the board and in turn presses the Board firmly

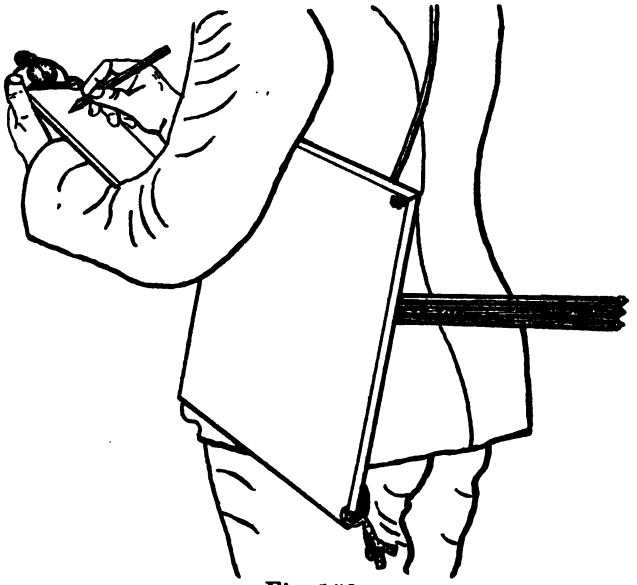

Fig. 153

against your side. If you have an assistant he should carry the Board, grasping the tripod at its top.

Immediately on mounting take the stop-watch-and-note pad (from the lower left blouse pocket) in the left hand, figure 150.*

*The stop-watch-note pad may be purchased through Secretary, The Army Service Schools at 35 cts. each. It consists of a piece of heavy cigar box board 2¾x9 inches, to which is glued

At the moment the horse starts, press the stop with first finger to start the watch, being careful to see it is set at the proper reading.

303. *Taking Notes on Horseback.*—As important details are passed along the road, note the time and opposite the proper line of the pad jot down a rough symbol on the center line or at the estimated distance from it, according as the location of the detail is on or off the road. These notes will be a great aid to the memory; but as little time as possible must be spent in putting them down, the greater part of the time being used to impress features of the ground on your mind. Some men find it very difficult to make even the simplest notes on a trotting horse; but you can learn to keep sufficiently clear notes on even the roughest horse, by standing up in your stirrups, leaning the body well forward and holding the arms close against the sides while writing. You can also record notes while posting. During the entire time spent in passing from one station to another, except for

the note pad shown. Each fifth horizontal line is marked to show minutes of travel. The three light lines between each two heavy ones represent 15 seconds (quarter minutes) each. The spaces between the vertical lines represent 100 yards each. The stop watch is secured to the back by two wooden pieces screwed on. The best type of stop watch is one which can be stopped and then will continue forward from this point when the stop is pressed again, so that continuous record may be kept over long straight courses. The watch should have a device for quickly setting the hand back to zero. A foot ball timer (price $1.50 Secretary Service Schools) is fairly satisfactory but not as reliable as a good stop watch. It is well to make a pencil holder on the side of the pad, as shown in figure, for a soft blunt pencil, so that the drawing pencil need not be used in taking notes.

the brief intervals required to record notes, you should devote every faculty to a careful study of the ground, the trace of contours, and other essential details.

304. *Distance Between Halts.* In the first two or three sketches you should not travel more than about one minute between stations. Later this distance may be increased as your skill progresses until you can travel for 3 or 4 minutes without halting. Suppose you pass a little draw on the road (at 1 minute and 15 seconds) falling to the left; a house distant 190 yards to the right at 1:30; an orchard on the left extending from 1:30 to 1:45; a ridge line at 1:30 found to be 850 elevation from your last station, extending 45 degrees to right front, with a —2 degree slope. These facts can be recorded in a moment as shown on the pad. Or some simple system of letters may be used, such as R for ridge, V for valley, on lines in the proper direction; an arrowhead for down slopes, etc.

305. *Procedure at a Station.* On arriving at a station, immediately upon halting press the stop to get the correct time. Dismount, throw the Board cord from over your head, release the needle, spread out the tripod legs, at the same time rotating the board horizontally to orient it. Back sight orientation is more accurate and will often be possible even when no tripod is used, by laying the board on the ground, and turning it until the last station is sighted. Waste no time in orienting.

The horse should be trained to stand without be-

ing held; but if necessary throw the rein over a post or place your foot on it (if you have no assistant). With tripod, you will find it easier to take your observations for direction kneeling on the opposite side of the Board from the point sighted. For sketching in details, however, a sitting position on the road side is best and most comfortable. After your traverse and other important directions are located do not worry about keeping an exact orientation during the work of sketching details. As soon as your Board is oriented plot your present station; pick out and sight your next forward point, also take any intersection or forward check sights, so that exact orientation will then not be so necessary for the remaining work. Determine the elevation of your present station with reference to the last known point by the methods heretofore given, that is with clinometer and M. D. scale, or barometer, or estimation, etc., according to the practice you have had. Locate any other necessary elevations and plot all details and contours up to your position. After several sketches have been made, you can begin to plot details forward from each station for about 15 seconds of travel, by estimation. This will relieve you of the necessity of taking notes until about 30 seconds have been passed. Move to next station using the same methods.

306. In rapid sketching, time may be saved on roads with frequent bends by *halting only at each alternate* bend. For example from E draw a ray

to F, noting the time of passing F but not halting there. At *G* plot *f* on the ray drawn from E; orient by needle, and pivoting the ruler on *f* draw a ray toward *G*, plotting on this ray the position of *g* from the time scale.

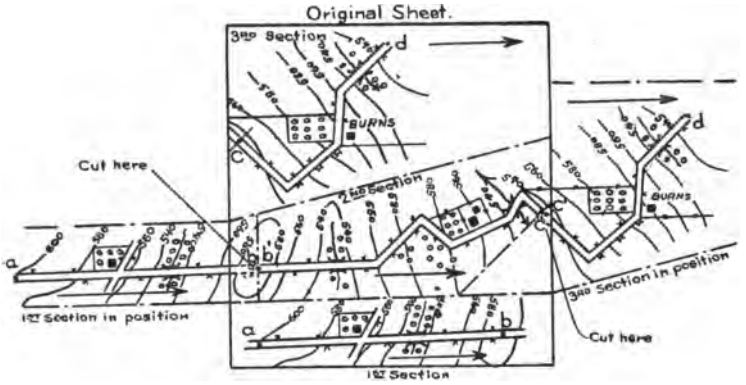

Fig. 154

307. *In case the sketch runs off the sheet* beyond *b*, figure 154, draw in the details a few yards *in front* of station B. Then assume a new point (*b'*) near the edge of the sheet, also to represent B, so chosen that the sketch forward from here will fall across the longest dimension of the unused part of the sheet. On the sheet near *b'* sketch in the details a few yards *in rear* of B, before moving forward. If no space is available on this sheet replace it by one of the extra sheets carried under it on the Board. When the sketch is completed, cut apart its different sections (on the broken and dotted lines) and place them together with all meridian edges parallel and *the two corresponding points on the sheets for any ground point, lying one directly*

over the other. Lay the ruler perpendicular to the traverse through the station point (as *b*) and cut both sheets through on this line. Remove the two ends cut off and join the parts together *without overlap* by means of adhesive tape or on another piece of heavy paper. Join up the details across the cut edges. Where the sketch is made on tracing paper and reproduction is required, the adhesive tape should be used. B, C, etc., should be on a straight portion of the road and *not at a bend,* to aid in orienting the sections.

308. The *rate of sketching* possible by these methods should be about 2 to 2½ miles per hour for men of average ability, after a month's practice. Men with greater aptitude can make from 3 to 4 miles per hour; and the best sketchers can make as much as 5 miles per hour. These rates refer to the *completely finished* sketch, ready for use. In ordinary service 2½ to 3 miles an hour would be sufficient, but the more rapid methods are very valuable for making a reconnaissance in a limited time, and of especial value to staff officers in reconnoitering routes and positions.

EXECUTION OF PLACE SKETCHES.

309. A Place sketch is made under the supposition that the sketcher is limited to a single point of observation overlooking the area to be sketched. The details to be shown are the same as on a position or outpost sketch. If made to extend a road or position sketch farther toward the enemy than can be reached by the sketcher the place sketch will

be on the scale of the sketch thus extended, otherwise at 6 inches=1 mile, 10 foot contours.

The sketcher must have acquired considerable skill in sketching and in making estimates of distances, slopes and elevations before he can successfully make a place sketch. The methods of work heretofore described for position sketching are followed except that all control points are located by determining distance with range finder (or by estimation), elevations with clinometer (or by estimation), horizontal angles of direction, with plane table or compass. For use of range finder see par. 214, *Military Topography*. First locate stream lines, next roads, then hill tops, and finally contours and minor details.

The place sketch is made under the same conditions as a perspective sketch, but has the advantage that it represents truly to scale the features of the ground in their relation to each other as estimated by the sketcher, and to be interpreted need not be examined from the point occupied by the sketcher. The sketcher's estimates may be in error, but his sketch will show the ground according to these estimates. A perspective drawing, on the contrary, furnishes no means of determining relations of distance, slope and elevation. They are valuable, however, for persons ignorant of map reading, or to illustrate descriptions of military positions for non-military readers. All staff officers and especially artillery reconnaissance officers, should be skillful place sketchers, since this ability will save the time ordinarily used in explanation of important features of the terrain to battery or

battalion commanders and enable the batteries to open fire more quickly and accurately than otherwise.

POINTS TO BE OBSERVED IN SKETCHING.

1. *Be sure your intersection and resection points are well marked to avoid sighting back on the wrong point.*

2. *Study your area carefully and do not sight any point that is not going to help your work. There is a tendency with all beginners to try to show too minute details and to take too many controlling points. A few minutes used in studying the area before commencing work will usually be well spent.*

3. *Keep constantly in view the scale of your sketch, the contour interval, and remember the smallest distance that can be shown.*

4. *Be sure your orientations are correct and that the Board is clamped after orientation. The forward sight to the next station should be made as soon after orientation as your position is plotted.*

5. *After the first set up always orient by a back sight if possible, especially if in the vicinity of iron, or strong electric currents. However, if you can't locate a point in rear to orient on, use the needle wihout hesitation.*

6. *Do not leave a station until all the details up to that point are put in. You may not have time to return that way. Finish your sketch as you go,* the lines may be retraced and the sketch cleaned up indoors if the emergency demands it, but all

data should be put on in the field. *You should make it a fixed rule to have a finished sketch up to the point occupied, before moving on to another.*

7. *Try to put equal care and time on all parts of the sketch.* Avoid excessive care at first followed by excessive haste near the end. A good sketcher should be able to do from one to two square miles of accurate sketch per day depending on the difficulty of the ground.

Note: For Exercises in sketching see par. 347.

CHAPTER V.

TOPOGRAPHICAL RECONNAISSANCE REPORTS.

310. *Reconnaissance* is the military term used to designate the work of troops or individuals when gathering information in the field. The general subject of Reconnaissance is divided into two parts: (1) that which relates especially to the strength, position and intentions of the enemy, and (2) that which relates especially to the terrain in its relation to the military situation.

Reconnaissance of the enemy is within the province of tactics and is treated under the head of the Service of Information in the Field Service Regulations.

311. By *Topographical Reconnaissance* is meant the obtaining and recording of all the needful information of a portion of the terrain in the shortest possible time and within the limits of accuracy required for the operations of troops in the field.

A Topographical Reconnaissance in general consists of:

1. *A Sketch.*
2. *A Report.*

The method used to secure and record the desired information of the terrain are therefore treat-

ed under the two headings, Military Topographical Sketching and Topographical Reports.

As much as possible of the desired information should be shown on the sketch, on account of the greater clearness and brevity thus secured. The report should amplify the sketch in matters which cannot be shown thereon, such as conditions of roads, quantities of supplies, etc. It should in general be written on the face of the sketch sheet in tabulated form; or on a letter size sheet of paper attached thereto.

For the means and methods used in making Military Sketches, see Part III, pars. 223-309.

312. *Military Topographical Reports: The Report should relate only to those subjects which are required by the orders for the reconnaissance so that no time may be wasted in gaining irrelevant information. It should be written clearly, and be as brief as possible* consistent with clearness. The *paragraphs* should be *numbered* serially for ready reference. *References* to the sketch should be made by means of numbers enclosed in parenthesis, thus: *"Road* (1)—(2) 18 *feet wide, macadam, good repair."* It is well to place all numbered references on the sketch before writing out the complete report so that these references on the sketch will extend from beginning to end in order and thus be easily referred to. It is a good plan to make these references on the sketch in red pencil so that they will catch the eye at once. The report should be dated and signed by the officer making the reconnaissance.

Names of Places should be in BLOCK CAPITALS, and should be spelled phonetically when the spelling and pronunciation are different. *Relative Terms* (such as before, behind, etc.) should be avoided, points of the compass being used except that the terms "right," "left" are to be applied to the banks of a stream assuming the writer to be looking down stream. The term *"open country"* means that it is free from hedges, undergrowth and other obstacles obstructing view and passage; *"close country"* is the reverse of this.

313. A *Road Reconnaissance* should procure data on the following subjects:*

314. *The Road*: *Gradients, especially the steepest;* width of roadway; if paved, width, kind and condition of paving; width and depth of side ditches, and whether wet or dry; if not paved, character of soil, sand, clay or gravel; *kind of fences* and width between them. The sketch should also show whether the road is an *embankment* or *cutting*; where wagons cannot double or pass, and where foot troops cannot march along the side between the wagon track and *fences; commanding heights within infantry or artillery range.*

315. *Bridges*: Material of piers and abutments *type* and *material of superstructure,* as *girder, truss, arch, suspension, wood, steel, stone* etc.; *width or roadway,* and clear headroom; safe load.

*From the Engineer Field Manual. Items of a reconnaissance, shown in *italics* should usually be shown by the sketch; those in ordinary type by the report. Features not fully shown in the sketch are amplified by the report.

Of bridges over the road, clear width and height; over streams, the nearest bridge above and below and whatever information can be obtained about them.

316. *THE COUNTRY.—Character of cultivation or natural vegetation; areas and density of timber, underbrush, vines,* especially poisonous ones; *marshes and fords, kinds of fences,* nature of soil, *general configuration of surface, especially high hills, long ridges or valleys, bluffs or slopes too steep to scale, and practicable routes to their crests.*

317. *STREAMS CROSSED.—Name, location, width,* depth and surface velocity in swiftest current; velocity noted as sluggish, moderate, quick or swift; elevation of high water marks in relation to the road; *which bank is the higher at crossing and above and below, and how much;* accessibility of water for stock; *fords at or near crossing;* length, depth and *steepness of approaches; levees or embankments, height and thickness on top;* if navigable, to what distance above and below and for what class of vessels—steamers, flatboats, rowboats.

318. *TOWNS AND VILLAGES* passed through—*Name, location on map,* and population. *Names of streets to be traversed.* Material, as stone, brick, frame, log; size, 1, 2, 3 stories; and distribution, close or scattered, of the houses in those streets; *gradients of intersecting streets; location of depots, post telegraph and telephone offices; of*

drinking fountains and watering troughs; of elevators, storehouses, or other accumulations of food and forage; of blacksmith, wagon and machine shops.

When ordered to make a complete examination of a town or village, note besides the foregoing, *location* and size of *principle buildings, halls, court and school houses, churches, banks, jails,* and their ownership; sources, maximum quantity and distribution of water supply; sanitary conditions and disposal of wastes; *location of railroads, depots, freight houses, sidings, etc.,* for all roads entering from the surrounding country the same information as scheduled above for streets; *location* and extent of *open spaces,* and of *large substantial buildings standing apart; location and extent of high ground within range, especially that from which streets can be enfiladed.*

319. *RAILROADS CROSSED.—Name, location,* gauge, *single* or *double track, sidings, and loading platforms at point of crossing; crossing at grade, over or under; distance, and name of nearest station each way; direction of nearest roundhouse, shops, etc.* General condition of stations as to defensibility—*command of surrounding ground,* and material of construction in the buildings.

RIVER RECONNAISSANCE.

320. If, when standing on the bank facing across the stream, the current flows from left to right, the observer is on the right bank; if from right to left, he is on the left bank.

321. *THE VALLEY—General configuration, heights of limiting ranges,* and *positions of passes and roads crossing them; commanding ground from which a stretch of the channel of considerable length can be enfiladed by artillery; forest growth on or near banks;* soil and cultivation of the valley; *roads parallel to river and means of access* to them from the river.

322. *THE STREAM*—Its *width,* depth and velocity, navigability, as for steam boats, row boats, and head of navigation for each; nature of obstructions to navigation and possibility of removing or avoiding them; season of high and low water, average rise and fall; rapidity of rise and fall and causes; amount of drift; character of *banks* and *relative command.* Quality of water, amount and kind of sediment borne; usual period and thickness of ice. (Ice 2 inches thick will support single men; 3½ inches will bear infantry in column; 10 inches will bear any military load.)

323. *Tributaries and Canals.—Width,* depth and navigability, *means of crossing.* Nature and purpose of canals; *dimensions* and lifts of locks; time for lockage; means of destroying locks and effect of destruction; floating plant found.

324. *Bridges and Fords.—As in road report.* Also for bridges note position of the channel and navigable width between piers; height of arches and lower chords above the water at different stages; dimensions and operation of draw spans. Note the *exact position of fords* and marks on both banks

by which they may be found; length, width and nature of bottom; velocity of current; position of deep holes; aids to crossing. Fords should not be more than 4 ft. 4 ins. for cavalry, 3½ ft. for infantry and 2 ft. 4 ins. for guns and ammunition. Note nature of approaches to bridges and fords; width of roadway, slopes, soil, effect of water and traffic. Note especially the defensibility of bridges and fords.

325. *Ferries, Boats and other means of crossing.—Position of ferries and approaches,* practicability for horses and loaded wagons; size, number and kind of boats; method of propulsion; sites for military bridges or ferries; character of site for construction, use and defense; *proximity of islands and other tributary streams;* approaches and slope of banks; width of river and maximum surface velocity of current; materials for the construction or repair of boats, bridges or ferries.

326. *Inundations.—Places suitable for inundations by damming or obstructing a narrow bridge span,* or *by cutting a levee or dyke.* Note raised roads on ground liable to natural or artificial inundations and the safest routes to follow by known land marks when the road is overflowed. (An extensive inundation 2 ft. deep on level ground is a serious obstacle unless the roads are very sound and marked by trees, posts, etc. Even when so marked a dip in the roadbed of 3 or more feet may render the road impassable. A railroad bed is soon washed out even by a slight overflow.)

RECONNAISSANCE OF A RAILROAD.

327. *The line. Local name, terminal points and distances between stations and other points;* gauge; *single or double track;* condition of roadbed, ties and rails; drainage and liability to overflows or washouts; facilities for repair; condition of right of way for marching troops along the line.

328. *Tunnels and Bridges.—Number and location; dimensions;* strength of bridges; means of destroying and repairing; of blocking traffic.

329. *Rolling Stock.*—Number and nature of engines and cars available; capacity for transporting troops between given points; facilities for constructing armoured trains, as spare rails, old boilers, etc.; *location* and capacity of the shops and store yards.

330. *Stations:—Name and location*; facilities for entraining and detraining troops with wagons and horses; platforms on through line and *sidings, ramps; side tracks, number* and capacity; *turn tables; water tanks;* fuel supply; storage facilities; derricks or cranes; *cross-over for teams* and pedestrians. Facilities at hand for hospitals, camps, depots; for feeding men, heating coffee, watering horses during temporary halts.

RECONNAISSANCE OF A WOOD OR FOREST.

331. Note *all roads and paths,* and *all hills, ravines, and streams within the wood or skirting the edges;* kinds of trees, *density of growth;* underbrush, prevalence of poisonous shrubs and vines; *marshy or large open spaces;* practicability of

forming new roads by cutting: creation of obstacles by felling trees; if there are no roads, *traverse the shortest practicable path between the point of entrance and the point of exit,* and mark boulders or blaze trees, set stakes or otherwise indicate this path, and also give compass bearings of the route to be followed. Note the *exterior from the woods, whether parts of the edge flank other parts; connection with neighboring pieces of wood by scattered trees or clearings; undulations of the ground that would give cover to attacking force or to defenders.*

RECONNAISSANCE OF MOUNTAINS.

332. Note the *number and positions of passes through the mountains, of roads and trails leading to these passes,* their condition, practicability, and means of repair; *steepness of slopes on the sides of roads;* means of constructing additional roads; *water courses, their direction,* nature, and time of floods, *means of crossing.* Note *ravines* and *open glades on mountain sides, lookout points,* and *good signal stations;* note time and duration of snow drifts on roads or passes; depth of drifts and possibility of removing them or traveling on the surface of the snow. Note *extent* and nature of *forest growth.*

RECONNAISSANCE FOR A CAMP OR WINTER QUARTERS.

333. *Site, location, elevation, and area;* sanitary features, such as drainage, dryness, and general character of top soil; *proximity of swampy*

ground or stagnant ponds. For camp of a regiment of infantry (65 men per company) allow approximately 280x350 yards; for a squadron (3 troops of 65 men each) 110x280 yards; for a battalion of artillery 280x400 yards. (For requirements of camp sites see F. S. R., Art. VI.)

334. *Communications.*—Sufficiency of existing *roads and paths, maximum grades,* probable condition under heavy traffic and in bad weather, location and kind of materials available for improvement or repair; *railroad or water communications* and *terminal facilities of same.*

335. *Water and Fuel.—Location,* kind and quantity of fuel at hand; quality and quantity of water, facilities for filling water carts, for watering animals and for washing and bathing; nature of supply, as wells, springs, running streams, and its reliability.

336. *Shelter and Conveniences:—Proximity* of trees, brush, wood, hay, and straw for huts and bedding; *of markets; of towns and villages.*

RECONNAISSANCE OF A POSITION.

337. This problem usually includes the selection of the position and is therefore tactical as well as topographical. Certain relations and conditions must be observed in the selection and the extent and degree in which they are found must be shown on the map or in the report. *The position and ground in front* to artillery range, to be shown by a contoured sketch at 6 inches to 1 mile.

338. *The length of the position* should be proportional to the force available for its occupation. Exact rules cannot be given.

339. *The flanks must be secure.* Impassable natural features, a *river, a mountain* or *stream* form the best flank. Lacking these, a *wood,* a *cliff* or a *high hill* will serve. Even with these features absent the flank may be strengthened by the construction of a strong earthwork, but the general rule obtains that natural weakness of the flanks must be made up by a greater number of men or by the substitution of cavalry for infantry in case the ground favors the movements of mounted troops. If the flanks are naturally strong the line should be withdrawn to make the entire position reentrant; if the flanks are naturally weak, the connecting line should be held so as to make the position straight or salient.

340. *The depth of the position,* or its extent in rear of the firing line, should afford natural cover for supports, reserves and trains, which may require a total depth of 800 to 2,400 yards; but a short position may be relatively shallower than a long one. Three or four *parallel ridges,* 300 to 600 yards apart, with the intervening ground practicable, forms an excellent position. If the first ridge is somewhat higher than the rest, so much the better. *What cover there may be for the component parts of the force, whether natural or artificial, fences, ditches, trees, etc., should be shown* or described. If digging is necessary, its amount and the character of the soil should be stated. *Strong points in*

front of the line, which may be occupied as outposts should be shown.

342. *Communication* should be free in every direction, concealed so far as possible from the enemy's view. *All communications* perpendicular and parallel to the front to be shown on the sketch.

343. *Artillery positions* are required when that arm is represented in the occupying force, as will usually be the case. They should permit the guns to sweep all ground in front of the position over which the enemy can advance, to the limit of effective range. Every point in front of the position and within range which commands any part of it is an element of weakness.

344. *Ranges* at which the enemy can be seen and reached by artillery fire, the *points beyond rifle range covered* by such fire and its *relative command of adverse artillery positions should be shown* or described. If possible *similar information* should be obtained of the *ground likely to be occupied by the enemy* in forming for attack or in taking up a counter position.

345. *A position occupied by the enemy* must be reconnoitered from a distance and few details can actually be seen. Valuable inferences may be drawn by remembering that the enemy has probably chosen his position according to the principles above given.

346. *Flanks.*—Especial attention should be given to the flanks and to the feasibility of turning one of them.

CHAPTER VI.

EXERCISES IN SKETCHING.

347. Sketching consists of measurements and estimates of relations on ground and maps, and more or less mechanical operations with pencils and scales. There will be a large number of distinct operations in any single sketch. And though each individual operation is in itself simple, yet the beginner who attempts at first to draw a complete sketch is invariably lost in a mass of details, imperfectly understood after a more or less careful reading of the text. Consequently, it is important that each detail be mastered singly; not by a study of the text alone, but by study supplemented by practice on the ground. To assist beginners in sketching who have no instructor, and as a guide for a systematic method to be followed in the instruction of classes, the following exercises on the ground are suggested. These exercises should be conducted in the vicinity of the Post on ground which has been previously sketched by a good sketcher or of which an accurate map exists:

348. Area 1. For position, outpost and place sketches, an area about ½ to 1 square mile is sufficient. Scale 6″=1 mile, V. I.=10 feet.

Area II. For road sketching exercises a road sketch or map about two miles long is necessary.

Scale 3″=1 mile, V. I.=20 feet. Each beginner should be furnished blue prints of these areas.

EXERCISES.

349. The work should be taken up in the following order: frequent indoor practice in tracing the contours on a well drawn map, in order to acquire facility in representing the forms later to be observed on the ground; then position sketch, outpost sketch, road sketch, place sketch. The paragraphs of the text referred to should be diligently studied before the particular exercise is undertaken, and should be read as necessary during the exercises.

POSITION SKETCHING.

Exercise 1.

(a) Determine your stride (pars. 228, 229).

(b) Make a working scale of strides (par. 229).

Note: Those who have difficulty in making scales may secure them of any desired length of stride or rate of speed from the Secretary Service Schools.

(c) Test the correctness of the scale (par. 230) and make any necessary changes in it.

Exercise 2.

Choose in Area I some road or path having frequent changes of direction and varying slopes. Traverse this road (par. 268, 278) plotting only the double lines (for width apart of bounding lines of roads see figures 148, p. 284 and 152, p. 302) or a single dotted line for the path. Halt (a) at every change of direction, (b) at every change of slope, (c) often to estimate the distance to points

in advance on the route. The halt (a) is first for the purpose of noting and plotting the new direction on the sketch (par. 237); the halt (b) is made to estimate the slope, par. 251, and difference of elevation (par. 258) from top and bottom of the slope. Having made all of these estimates as carefully as possible, check each of them by comparison with the blue print, using the scale of M. D's. to verify the slope, the marked elevations or contours to check elevations; the counted strides to check the distances.

Now having fixed to your satisfaction the slope between the two points, space in the contours along that slope on your sketch by eye, checking the estimate with scale of M. D's. (par. 272). Next note the number of contours along this slope from the difference of elevation between its top and bottom (par. 273). Space these by eye to show the particular kind of slope (par. 272). Check the results from the blue print.

Repeat the above exercises until (1) your length of stride is accurately found (2) you thoroughly understand the methods of orientation and plotting of the traverse and the making and verifying of estimates.

Note: Exercise 2 is to develop a fixed habit of verifying all estimates. Rapidity comes later.

Exercise 3.

Traverse the same road as in exercise 2, performing the same operations and in addition, locate by intersection (par. 269), (a) the top of each hill, (b) the juncture of each two streams and water

flow lines, and their heads on both sides of the traverse for ½ mile. Use field glasses to pick out definite points to sight on and see if you are at any time unable to get a second observation on any point sighted. If so find out why, and try it again. Much time is wasted by taking one observation on points and then not finishing their location.

Next move back over the traverse and (a) estimate the slope to each point located, (b) check the estimate by reading the slope with clinometer (par. 251). Then estimate the difference of elevation from your stations to these intersection points. Space the contours by eye, checking etc., as in exercise 2 for work on the traverse.

Exercise 4.

Having traversed the road in exercise 2, set up your board (par. 268) at a station on it, and plot the direction of three or four hill tops off the road. Move to one of these hills and set up in the direction line observed and locate yourself by resection (par. 270). See how this location agrees with that by intersection on this point. Repeat on each of the other hill tops sighted, until you are entirely familiar with this method of resection.

Next locate points by resection using the needle for orientation (par. 270, 2nd method) and compare the results obtained with those by the first method of resection.

Exercise 5.

(a) Pick out a base line in Area I and see how well it fulfills the conditions of par. 277.

(b) Traverse this base (par. 278), locate critical points (par. 266) over the area by intersection and resection.

(c) Go back over the area and sketch in by eye the horizontal details (figure 147, p. 284, par. 276) such as streams, water flow lines, roads, railroads, telegraph lines, trails, crest lines of ridges, hill tops, orchards, houses, etc.

Exercise 6.

(a) Begin at your initial station and locate the elevations of all critical points by estimation (par. 257), checked by slope readings and application of scale of M. D's., par. 272.

(b) Having found the elevations of the critical points space in the contours by eye, par. 284, checking with the blue print.

Exercise 7.

(a) Make a complete sketch of the flat details as in exercise 5 on an entirely new area.

(b) Contour the above as in exercise 6, par. 283.

Exercise 8.

Make the complete sketch of the area in exercise 7, showing at the same time all horizontal details and the contours par. 286. In this exercise finish up all work in rear of each station (par. 282) before leaving it.

Exercise 9.

(a) Select an outpost line and traverse this as a base (par. 278) at the same time locating crit-

ical points as far to the front as the ground is visible (par. 288).

(b) Return along the base drawing in all horizontal details and contours as indicated in preceding exercises.

ROAD SKETCHING.

Exercise 10.

(a) Make your scale of strides at 3″ to 1 mile, par. 229.

(b) Rate your sketching horse (par. 231) at a walk and trot.

(c) Construct a scale of walk and of trot (par. 232 and par. 19, prob. 3).

Exercise 11.

(a) Traverse (par. 291 et. seq.) the road area II, dismounted, locating all flat details on the road, and, by intersection, to within 400 yards on each side. Each point should first be estimated as an offset (par. 271) and then checked by careful location.

(b) Go back over the road and contour it by estimating the elevations of critical points, par. 257, and the contour spacing, par. 272.

Note: Remember that contours are spaced the same distance apart for the same slopes on both road and position sketches (par. 226).

Exercise 12.

Make a complete contoured sketch carrying on the horizontal locations and the contours together, along the road in exercise 11, par. 296.

Exercise 13.

Repeat exercise 11 mounted (a), at a walk (b) at a trot, par. 300.

Exercise 14.

Repeat exercise 12 at a trot, being careful to have a complete sketch up to each occupied station and about 15 seconds in advance before moving forward, par. 305.

Exercises similar to the above may be drawn up for place sketching following the principles in the text.